CLOSED PROXIMAL PHALANGEAL FRACTURE MANAGEMENT IN HAND

– AN OUTCOME ANALYSIS

A dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

in partial fulfillment of the requirements for the degree of

M.Ch.

(PLASTIC AND RECONSTRUCTIVE SURGERY)

Branch – III

DEPARTMENT OF PLASTIC SURGERY

COIMBATORE MEDICAL COLLEGE HOSPITAL

COIMBATORE

AUGUST 2015

CERTIFICATE

This is to certify that the dissertation " **CLOSED PROXIMAL PHALANGEAL FRACTURE MANAGEMENT IN HAND –AN OUTCOME ANALYSIS "** submitted by **DR.E.KOVARTHINI** to the faculty of Plastic Surgery, **The Tamilnadu Dr. M.G.R. Medical University,** Chennai in partial fulfilment of the requirement for the award of the degree**, MASTER OF CHIRURGIE IN PLASTIC AND RECONSTRUCTIVE SURGERY,** BRANCH III for the August 2015 Examination is a bonafide research work carried out by her under our direct supervision and guidance.

Prof. Dr. B.Asokan., M.S, M.Ch. (Plastic)
Prof. and Head of the Department,
Department of Plastic Surgery,
Coimbatore Medical College,
Coimbatore.

Prof. Dr. A.Edwin Joe M.D.B.L
The dean,
Coimbatore Medical College,
Coimbatore.

DECLARATION

I, **Dr. E.KOVARTHINI** solemnly declare that the dissertation titled **Closed Proximal Phalangeal Fracture Management In Hand – An Outcome Analysis** is a bonafide research work done by me at **Coimbatore Medical College** during 2012 - 2015 under the guidance and supervision of **Prof. Dr. B. ASOKAN, M.S., M.Ch., (Plastic).** The dissertation is submitted to The Tamilnadu Dr. M.G.R. Medical University, towards partial fulfilment of the requirement for the award of M.Ch. Degree (Branch III) in Plastic and Reconstructive Surgery.

Place : Coimbatore **Dr. E.KOVARTHINI**

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ACKNOWLEDGEMENT

I owe my thanks to **Prof**. **Dr. A. EDWIN JOE M.D B.L, The DEAN, COIMBATORE MEDICAL COLLEGE**, for allowing me to avail the facilities needed for my dissertation work.

I am greatly indebted to **Prof. Dr. B. ASOKAN., M.S.M.Ch. (Plastic)** Professor and Head, Department of Plastic and Reconstructive surgery, for his valuable guidance in completing this dissertation.

I am also deeply thankful to our associate professor**, Prof. Dr.N.SEKAR., M.S. (Ortho), M.Ch. (Plastic)** and Assistant Professors**, Dr.V.P.Ramanan Dr.R.SenthilKumar, Dr.S.Prakash and Dr.M.Sundararajan** for their valuable suggestions and inputs in preparing this dissertation.

I also thank our college **Ethics Committee** for their certification of approval. I also thank my co-post graduates for their help in preparing this dissertation.

Finally, I will be failing in my duty if I don't thank **my patients** who have been my greatest source of inspiration in my work.

DR.E.KOVARTHINI

Coimbatore Medical College

COIMBATORE, TAMILNADU, INDIA - 641 014

(Affiliated to The Tamilnadu Dr. MGR Medical University, Chennai)

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CERTIFICATE

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Course : Mch PLASTIC SURGERY

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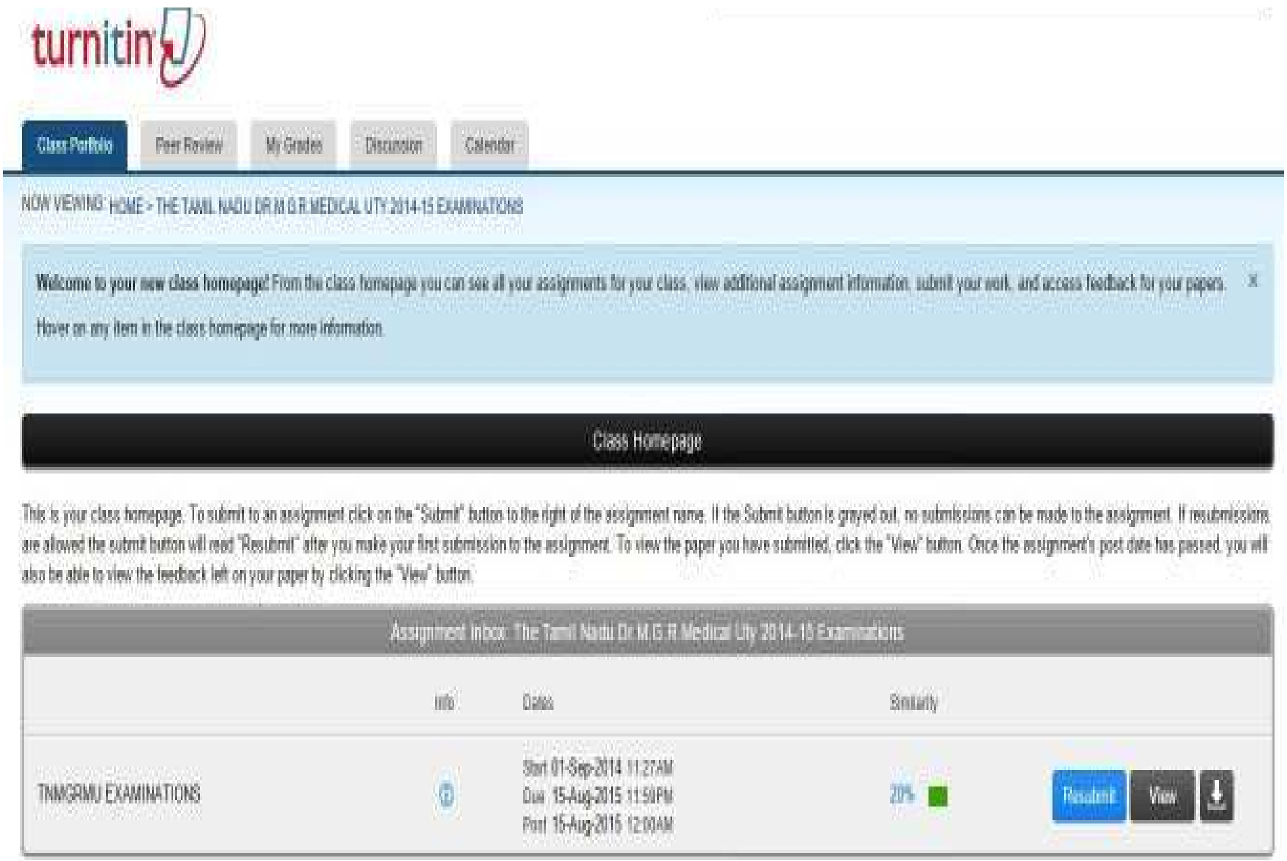
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1 INTRODUCTION

Commonest fractures in the upper extremity include fractures of phalanges and metacarpals. It accounts about 10% of fractures of upper extremity. Fractures commonly involve the outer rays. The proximal phalanx is the most frequently injured phalanx in the finger. In proximal phalangeal fracture displacement and deformity is obvious. Majority of the fractures are stable and can be treated with non operative methods. Outcome is better when treated with protective splintage and early mobilization. But the complications like malunion, stiffness and associated soft tissue injury make the outcome poor in closed treatment. Proximal phalangeal fractures with angulations more than 20 degree in AP view and greater than 15 degree in lateral view, rotational deformity, less than 50% bony contact, collapse and multiple fractures needs open reduction and internal fixation. Operative fixation must be used appropriately. Selection of the treatment depends on the fracture geometry, fracture location, deformity, and fracture stability, whether they are closed or open.

Final outcome is assessed by pain free union, residual deformity, total active motion of MCP, PIP, DIP joint, grip strength, pinch strength. In case of thumb outcome is assessed by palmar abduction and total flexion.

This is a descriptive study conducted in department of plastic surgery, Coimbatore Medical College Hospital from June 2013 to January 2015 involving 50 patients with closed proximal phalangeal fractures.

2 AIMS AND OBJECTIVES

1. To study the proximal phalangeal fractures based on causes, type of fracture, and finger involvement.

2. Planned for operative or non operative management based on type of fracture.

3. Follow up of patients for complications and restricted mobility of fingers.

4. Subjective assessment of functional outcome based on total active range of motion of MCP and PIP and DIP joint, pain free union, residual deformity, and in case of thumb by palmar abduction and total flexion and also surgeon's satisfaction.

5. Objective assessment of final functional outcome based on total active range of motion of MCP and PIP and DIP joint, pain free union, residual deformity, and in case of thumb by palmar abduction and total flexion and also patient satisfaction.

6. To provide reliable evidence of the effects of any instrumentation either non surgical or surgical can be used in the management of closed proximal phalangeal fractures.

3 REVIEW OF LITERATURE

3.1 HISTORY

Fractures of the phalanges and metacarpals are the commonest injuries that are presented to hand surgeons. Proximal phalanx and metacarpal fracture involves about 10% of all hand fractures. But 80% of all hand fractures involve metacarpal and proximal phalanx. Until the earlier part of twentieth century, these fractures were treated conservatively. In 1928, Albin Lambotte pioneered the work of open reduction and internal fixation for metacarpal fractures. Nowadays also most of the metacarpal and phalangeal fractures are treated non operatively. Those fractures that are minimally displaced or non displaced are mostly stable and require only conservative management. The unstable fracture or dislocation, like transverse or oblique phalangeal or metacarpal or shaft fracture, requires open reduction and internal fixation for maintaining the alignment. Percutaneous pin fixation for phalangeal fractures was first pioneered in 1924 by Tennant. He was using a phonograph needle for fixation. Kirschner only described the use of the small traction wires made from the piano wire in 1927. Bosworth first did closed reduction and percutaneous pinning of fifth metacarpal neck fractures using Kirschner (K) wires in 1937.

World War II created more opportunity for fracture fixation or sabilization. Bunnell and some others used K-wires for percutaneous fixations in the hand. In 1953, Vom Saalin reported the results after closed reduction and percutaneous fixation of different type of phalangeal and metacarpal fractures. After twenty years, Green and Anderson described the method of fixing the phalangeal fractures using crossed K-wires.

Clifford used Vom Saal's method in 36 patients with phalangeal and metacarpal fractures. Antegrade method of fixing metacarpal fractures using K wire was reported by Foucher in 1976. The fracture was reduced and closed, and multiple pins were passed by anterograde method inside the medullary canal and into the head of metacarpal. It avoided both opening of the fracture site and also injury to the soft tissues around the metacarpophalangeal joint. Although the reduction was good, the main drawback of this procedure was pin migration, shortening and inability to support the comminuted or spiral fractures.

New strategies were developed to overcome these problems by Vivesetal in 1981. He combined the method of introducing axial pin through base of the Metacarpal with an antirotation transverse pin introduced through the heads of the Metacarpals. Gonzalez and Hall used to fix the transverse and short oblique fractures by using the pre-bent flexible IM nails instead of K-wires. Orbay et al. introduced the fixation of flexible nails which was done by adding a proximal locking pin. It improves the rotational stability and minimizes shortening, This method also used to fix the long oblique, spiral and communited fractures.

1980's showed the advances in basic sciences that have led on to and also resulted from advances in the operative fixation of fractures. Corrosion-resistant alloys underpins were developed. Lot of techniques were developed from fixation of fracture in large bones and most of the materials used for surgery came from sewing boxes or workshops. At that time understanding of bone healing was improved and suitable application of mechanical principles for skeletal injuries followed. Emergence of Operative fixation of hand fractures was occurred and improved with its own right. [1]

To create minimally invasive techniques for PIP Joint fracture dislocations is a processwhich has gone through number of stages. Dynamic traction in external fixation mechanisms was began with “home made” use of multiple combinations of pins, rods made up of methyl methacrylate , springs, or rubber bands, and also included Schenk’s dynamic traction device which is having its circular frame which requires construction by a qualified hand therapist. Lower profile styles were developed later and included the Agee force couple system. The other hinged dynamic external fixator devices were popularized by Slade, Suzuki, Inanami, and some others.

The force couple process which includes three Kirschner wires and a rubber band. This process is designed to reduce the base of the middle phalanx volarly and the head of the proximal phalanx dorsally. The force couple process and the other hinged dynamic external fixators are built around centre of the axis of rotation of proximal inter phalangeal joint, which lies within head of the proximal phalanx. These methods are very low in cost and are readily available to any surgeon. However, some surgeons found these methods to be difficult to create and also more challenging and to establish and to maintain the reliably stable proximal inter phalangeal joint during the full range of motion. Some surgeons felt them to be cumbersome to the patients. In addition, there are some restrictions to their use. For example, use of Agee force couple splint which requires a stable dorsal portion of the base of the middle phalanx to resist the axial and the dorsal displacement of the PIP joint. Some of the complications and the limitations encountered with this technique led to the development of biomechanically robust and more easily reproduced method of alternatives. These are commercially offered systems which consist of the Smith &

Nephew Proximal Inter phalangeal Hinge, often referred to as the Compass Hinge and the Biomet Bio Sym Met Ric PIP Fixator.

In 1998 Elmaraghy et al. [2] presented a retrospective study of 24 patients with fracture in 35 digits which are unstable fractures of the proximal phalanx. Fractures were treated with percutaneous intramedullary K-wire fixation.

Outcome was assessed by,

Radiological, this shows adequate reduction

Total active range of motion

Development of contracture in joints,

Hand grip strength, grip strength in digits,

Good or excellent results were obtained in case of 76% of the fractures. The conclusion of this study was percutaneous intramedullary Krishner-wire fixation is a better method of treating unstable proximal phalangeal fractures. Good or excellent results were obtained in the majority of the patients.

In 2003, Horton et al. [3] divided the patients randomly with long oblique or spiral fracture of the proximal phalanx into two groups. One group was treated with closed reduction and K-wire fixation. The second group was treated with open reduction and fixation using lag screws. Outcome was assessed in terms of pain, movement, grip strength, and function. 32 patients included into this study, and 15 patients were treated with K-wire and 13 patients were treated with lag screw. Both groups were followed for 40 months. There was no obvious difference in the functional recovery and also there is no difference in the pain scores. Follow up X-ray was showed equal rates of malunion. There were no significant differences in total range of movement and grip strength.

In 2007, Stanton et al., analyzed 423 hand fractures (metacarpal and phalanx). They used X-rays to demonstrate that, 363 of them were extra articular and 70 were intra articular fractures. That shows 69% of fractures are extra articular and 31% of fractures are intra articular.

In 2008, Al-Qattan et al. [4] reported the study of patients with transverse fractures of the shaft of proximal phalanx which are unstable in nature. According to treatment, patients are divided into two major groups. First group was treated with closed reduction and percutaneous K-wire fixation Second group was treated with open reduction and loop wire fixation. In the follow-up second group had better TAM scores than first group. The complication rate was higher in the first group than the second group. (28% versus 11%). But difference did not reach the statistical significance (p=0.084).

Management of proximal phalangeal fractures is based on

The type of the fracture,

Amount of displacement in degrees

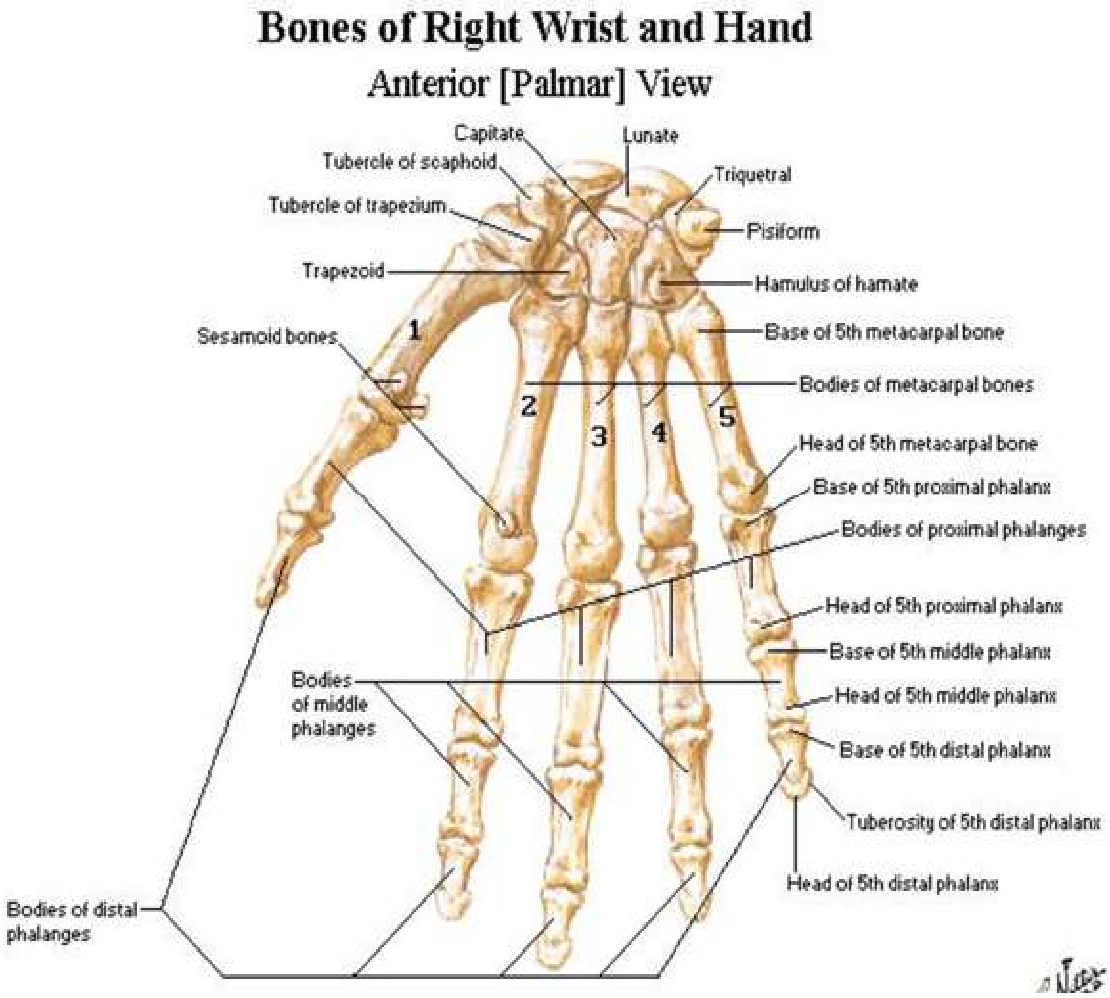
Difficulty in maintaining the fracture reduction.

A wide range of options available for management of the various fracture patterns. All stable fractures do not require any surgical treatment; but all other fractures should need surgical intervention. Lot of combined methods of internal fixation are available; K-wires and screw-and-plate fixation is the commonly used method. Plate fixation is used in communited proximal phalanx fracture and lag screws in spiral and long oblique phalanx shaft fractures.

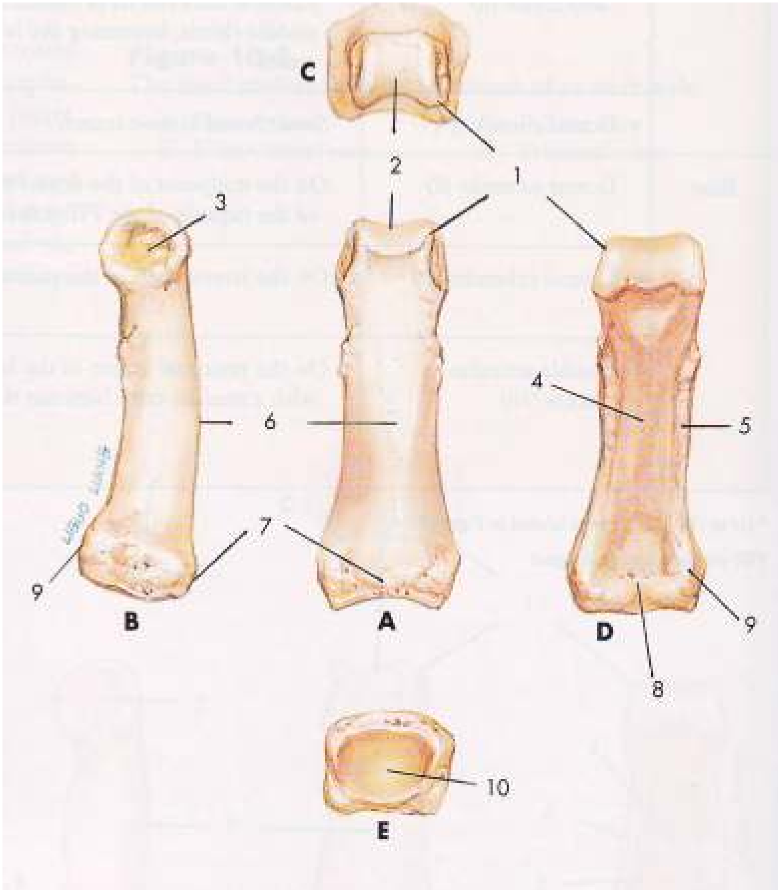
In summary, in the past three decades, closed method of fixation using flexible IM nailing has evolved as an alternative to plating techniques which is to treat the simple and the complex extra-articular fractures of long bones of hand.

3.2 ANATOMY

3.2.1 OSTEOLOGY OF HAND



3.2.2 ANATOMICAL FEATURE OF PROXIMAL PHALANX



Proximal phalanx from the left middle finger of an adult male.

A. Dorsal view.
B. Ulnar lateral view.
C. Distal view.
D. Palmar view.
E. Proximal view.
1. Condyle
2. Intercondylar space
3. Circular depression
4. Palmar concavity
5. Lateral ridge
6. Dorsal convexity
7. Dorsal ridge
8. Palmar depression
9. Lateral tubercle
10. Articular surface for the metacarpophalangeal joint

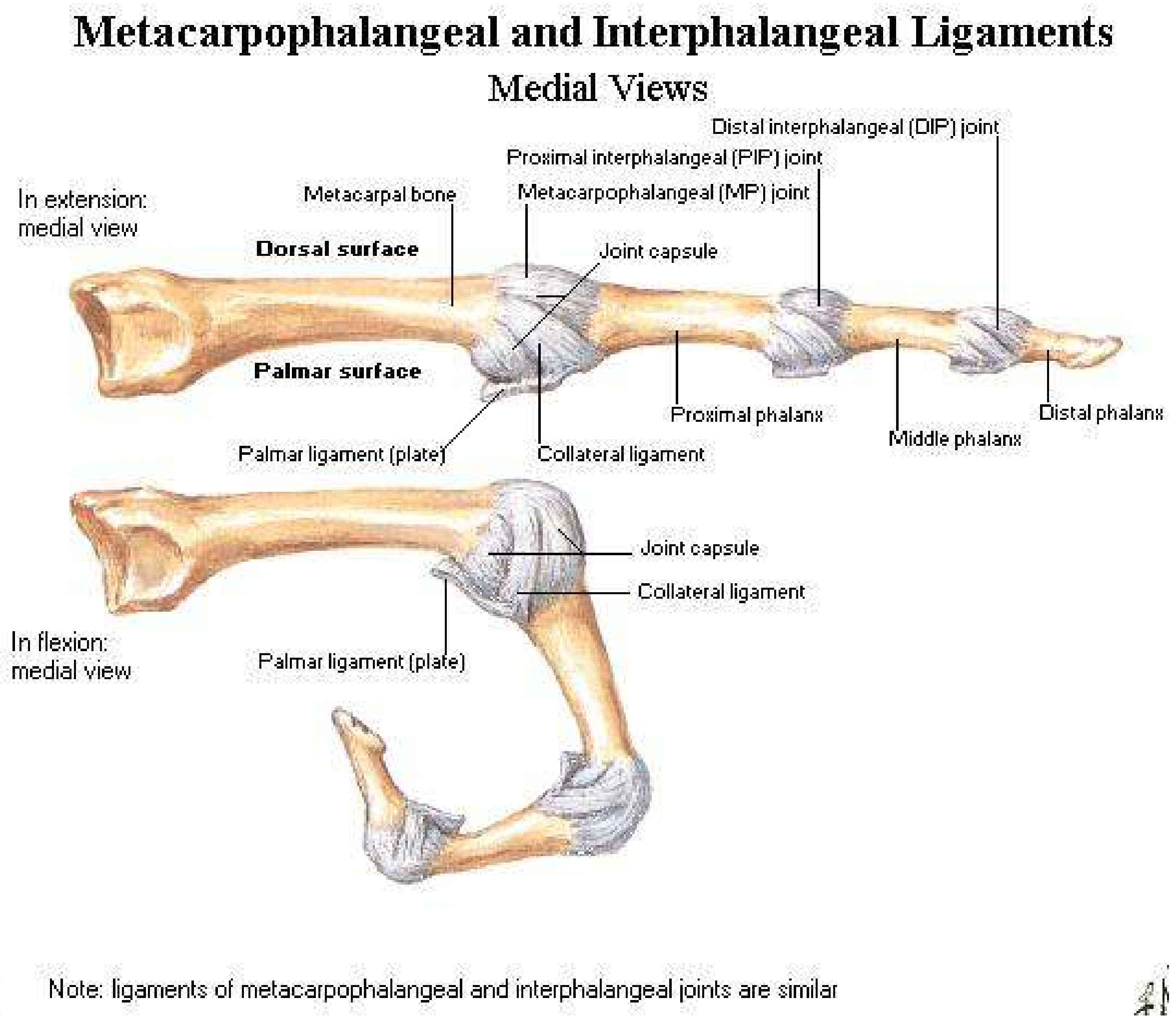
3.2.3 GENERAL FEATURES OF PROXIMAL PHALANX

TABLE 10-3. General Features of the Proximal Phalanx

	Anatomic Features	Description	Related Structures
Head	Two condyles (1)* and an intercondylar space (2)	Similar to the head of the middle phalanx.	Corresponding to the articular facets and median crest of the base of the middle phalanx.
	Circular depression (3)	Similar to the head of the middle phalanx.	For proximal insertion of the collateral ligament of the proximal interphalangeal joint.
Shaft	Palmar concavity (4)	More concave than that of the middle phalanx. Its bottom is flat and surmounted by a lateral ridge.	Passage for the flexor tendons.
	Lateral ridge (5)	Slightly rough; it ends distally at the junction of the distal and middle thirds of the phalanx. Proximally, it continues onto a lateral tubercle.	For attachment of the fibrous tendon sheath.
	Dorsal convexity (6)	Round and smooth.	Overlaid by the extensor apparatus.
Base	Dorsal ridge (7)	Somewhat smoother; there is no tubercle at its midpoint, as on the base of the middle phalanx; instead it has a slight rough area.	For attachment of the capsule of the MP joint. The rough area may sometimes be an inconstant insertion of the extensor tendon.
	Palmar depression (8)	At the middle part of the palmar ridge of capsule of the MP joint, between the lateral tubercles.	For passage of the flexor tendon.
	Lateral tubercles (9)	On the lateral ends of the palmar ridge.	For attachment of the collateral ligament.
	Articular facet for MP joint (10)	Single, oval, and concave, on the proximal aspect of the base.	Articulates with the head of the metacarpal to form the MP joint.

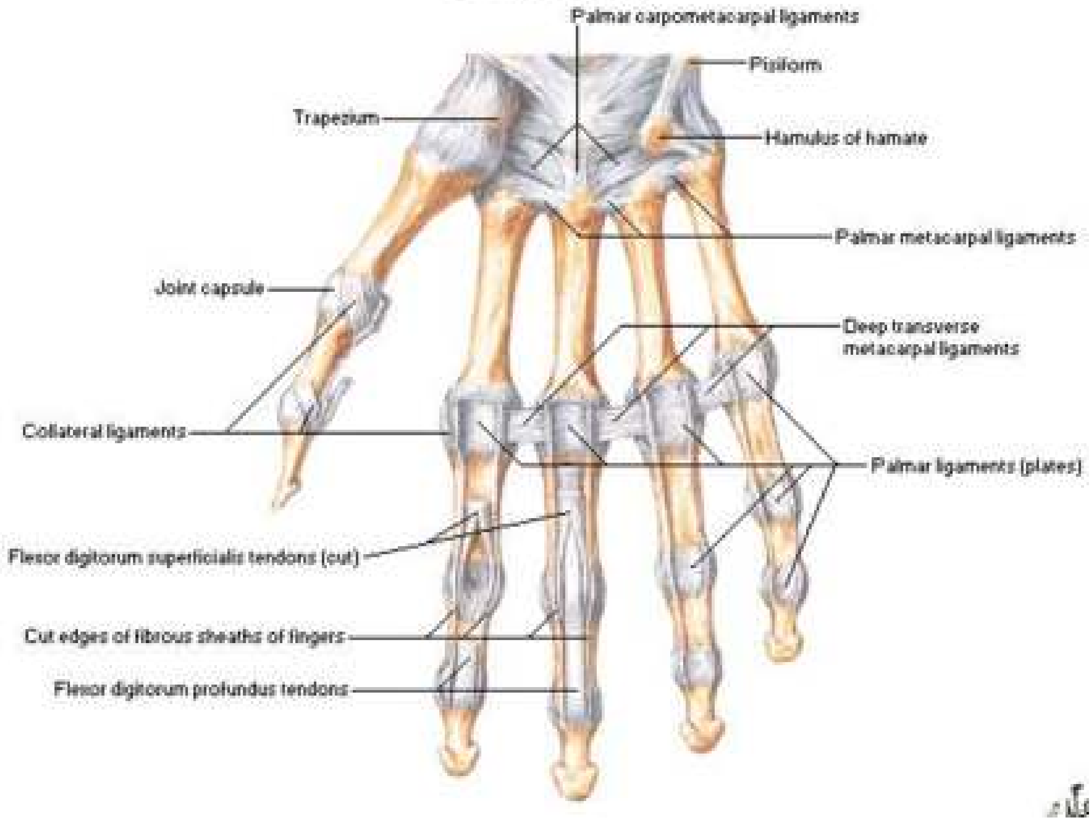
3.2.4 Normal Anatomy

The normal anatomy of the phalangeals, restraining ligaments, various components of the extensor apparatus, intrinsic muscle insertions, and flexor tendon system is depicted in Figure 1 and 2 (1).

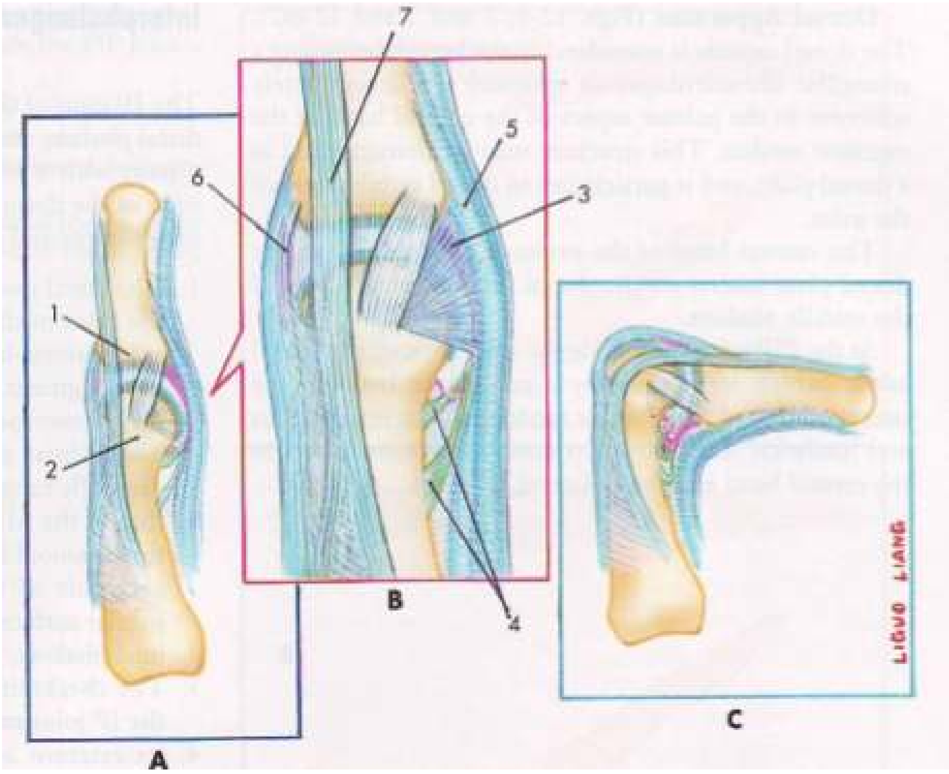


Metacarpophalangeal and Interphalangeal Ligaments

Palmar View



3.2.5 ANATOMY OF PIP JOINT



Anatomic structures of the proximal interphalangeal (PIP) joint (part I).

A. In a lateral view with the PIP extended, note that the collateral and accessory collateral ligaments are taut, similar to those for the DIP.

B. In the enlarged diagram, the anatomic structures of the PIP joints are detailed.

C. In a lateral view with the PIP joint flexed, note that the collateral ligament is still taut but the accessory ligament is loosened, similar to those for the DIP joint.

1. Middle phalanx
2. Proximal phalanx
3. Palmar plate
4. Checkreins of the palmar plate
5. Flexor tendons and sheath
6. Central band of the extensor tendon and dorsal plate
7. Lateral band of the extensor apparatus

3.2.6 Pathologic Anatomy

Fractures of the shaft of proximal phalangeal usually exhibit an apex palmar angulation [5]. Intrinsic muscle insertions after fracture, flexes proximal fragment, and the distal fragment is extended by the attachment of central slip to dorsal aspect of middle phalanx. In proximal phalangeal fractures usually the axis of rotation lies on the fibro-osseous border of flexor tendon sheath. The moment arm of the rotational axis of fracture site to extensor tendon is greater than the moment arm between the axis and the flexor tendons. So this also adds additional contributing factor to the apex palmar angulation. This palmar angulation gradually shortens the fractured proximal phalanx, so that the extensor mechanism reserve length up to 2 to 6 mm which occurs before the sagittal bands tighten which again tends to produce a progressive extensor lag at the proximal inter phalangeal joint. Every millimetre of bone–tendon discrepancy will produce about 12 degrees of extensor lag. [6]. A pseudo claw deformity develops, and leads on to joint contracture.

Digital rotation may occur in oblique fractures in addition to the above deformities. Overlapping or obstruction of the adjacent fingers may occur with flexion. A palmar fracture spike which may block adjacent joint flexion movement.

3.2.7 PATHOPHYSIOLOGY

The proximal phalanx is encircled dorsally and on both sides by the extensor apparatus and on the palmar side by the fibro-osseous tunnel, its adjacent flexor tendons, and the surrounding tendon sheath. Flexor tendon zone 2 (corresponds to proximal extensor tendon zone 3, all of zones 4 and 5, and distal zone 6) encompasses the proximal phalanx and is called no person's land because of the propensity for scar and adhesion formation with adjacent flexor tendon injuries that occur in this area. Phalangeal fractures create a similar response which is proportional to injury severity [7-10] .

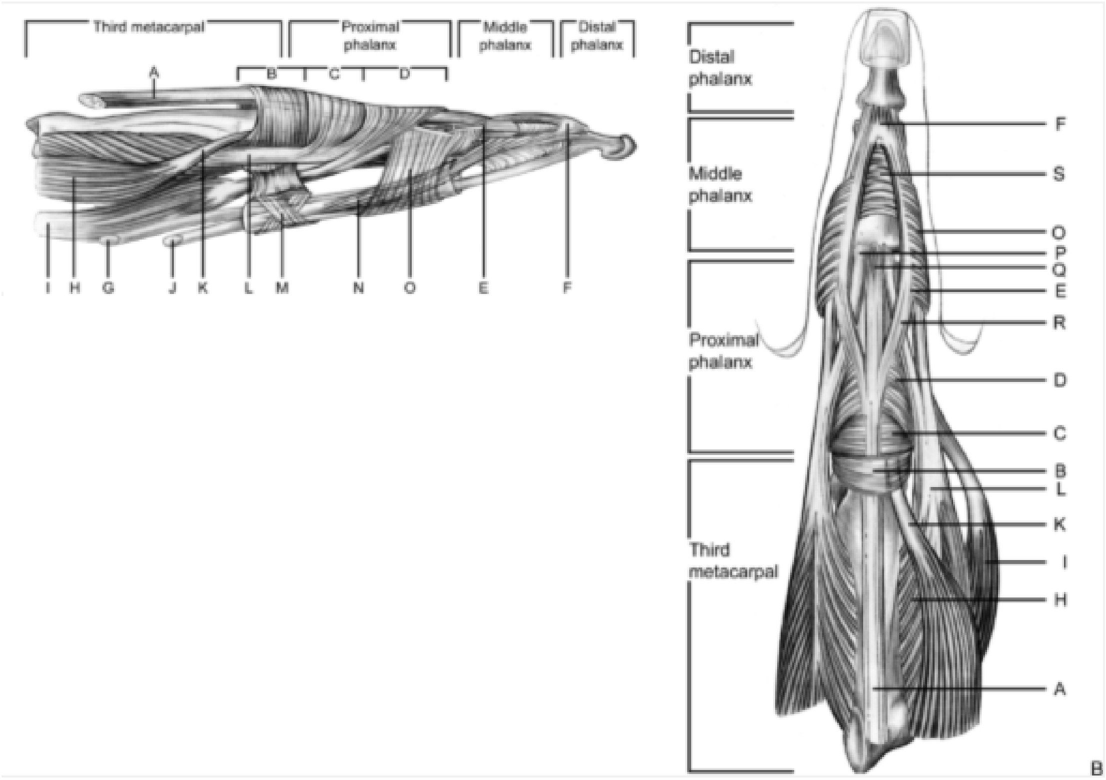


FIGURE 1. Diagrammatic representation of the soft tissue structures that are adjacent to the proximal phalanx of the finger. **A:** Lateral side, middle finger. **B:** Dorsum, middle finger. A, extensor digitorum communis tendon; B, sagittal bands; C, transverse fibers of the intrinsic apparatus; D, oblique fibers of the intrinsic apparatus; E, conjoined lateral band; F, terminal tendon; G, flexor digitorum profundus tendon; H, second dorsal interosseous muscle; I, lumbrical muscle; J, flexor digitorum superficialis tendon; K, dorsal interosseous tendon; L, lateral tendon of superficial belly of interosseous tendon; M, A1 flexor pulley; N, oblique retinacular ligament; O, transverse retinacular ligament; P, medial band of the oblique fibers of the intrinsic apparatus; Q, central slip; R, lateral slips; S, triangular ligament. (From Smith RJ. Balance and kinetics of the fingers under normal and pathologic conditions. *Clin Orthop* 1974;104:95, with permission.)

All the soft tissues within the zone of injury will develope contracture. ("one wound–one scar"). Thus, comminuted or open phalangeal fractures, multiple hand fractures, and complex wounds, which often result from crush injuries, substantially compound this reaction and also increase the risk of digital stiffness.

Because the operative intervention represents an additional injury, operative treatment must be selected judiciously. Successful operative outcome depends on the principles applied during internal fixation.

3.3 CLINICAL EVALUATION

3.3.1 History

A thorough history of the injury and a physical examination of the hand are important in the evaluation of any fracture in the hand. A careful history gives personal data, social data, and demographic data, such as age, dominant hand, and the occupational status of the patient, as well as the cause for the fracture and the possibilities of other injuries.

3.3.2 Physical Examination

On examination, first one should identify the area of maximum tenderness; the location of fracture, type of fracture, and the severity of any other deformities or the presence of open wounds. Condition of all the flexor and the extensor tendons also examined along with the neurovascular status of the hand. Shortening, angular and rotational deformities should be noted by clinical and radiographical method. Wrist block or digital block will be helpful during surgery which facilitates the static and dynamic assessment of deformity, fracture stability and digital motion.

3.3.3 Imaging Studies

X-rays are usually enough for the evaluation of phalangeal fractures which includes AP and lateral views of the involved digit. A true lateral view is helpful in accessing angulation in the sagittal plane. In addition to that the oblique views are useful in defining the configuration of fracture, fracture displacement, deformity of the finger, relationship of the fragments, and fracture extension into the articular surface.

3.4 FRACTURE MANAGEMENT PRINCIPLES

These principles include anatomic (or near anatomic) position or reduction, adequate stability to allow fracture healing and early active digital motion, and minimizing additional soft tissue damage when fracture fixation is required.

3.4.1 FACTORS INFLUENCING OUTCOME AFTER PHALANGEAL FRACTURES

FACTORS INFLUENCING OUTCOME AFTER PHALANGEAL FRACTURES		
Patient Factors	**Fracture Factors**	**Management Factors**
Age	Location	Diagnosis and recognition
Associated diseases and arthritis	Articular fractures	Reduction and maintenance
Socioeconomic status	Geometry	Length of immobilization
Motivation and compliance	Simple, comminuted, impacted, bone loss	Recognition and management of complications
	Transverse, oblique, spiral, avulsion	
	Deformity: angulation, shortening, rotation	
	Stability	
	Injury to soft tissue sleeve	
	Associated injuries	
	Tendon, ligament, joint, vessel, nerve, other digits	
Modified from Strickland JW, Steichen JB, Kleinman WB, et al: Phalangeal fractures: factors influencing digital performance, *Orthop Rev* 11:39-50, 1982.		

Table 8.5 Factors Influencing Outcome after Phalangeal Fractures

3.4.2 ALGORITHM

The fracture management principles have helped to develop an algorithm for phalangeal shaft fracture management. First the surgeons must assess the type of fractures and formulate the operative plan. He must believe that is the best management for that particular fracture type. There may be various type of method that can provide the comparable outcome. Treatment supervision, patient compliance, and adherence to the aforementioned principles of fracture management is more important than the method, implant, or implant configuration that is choosen.

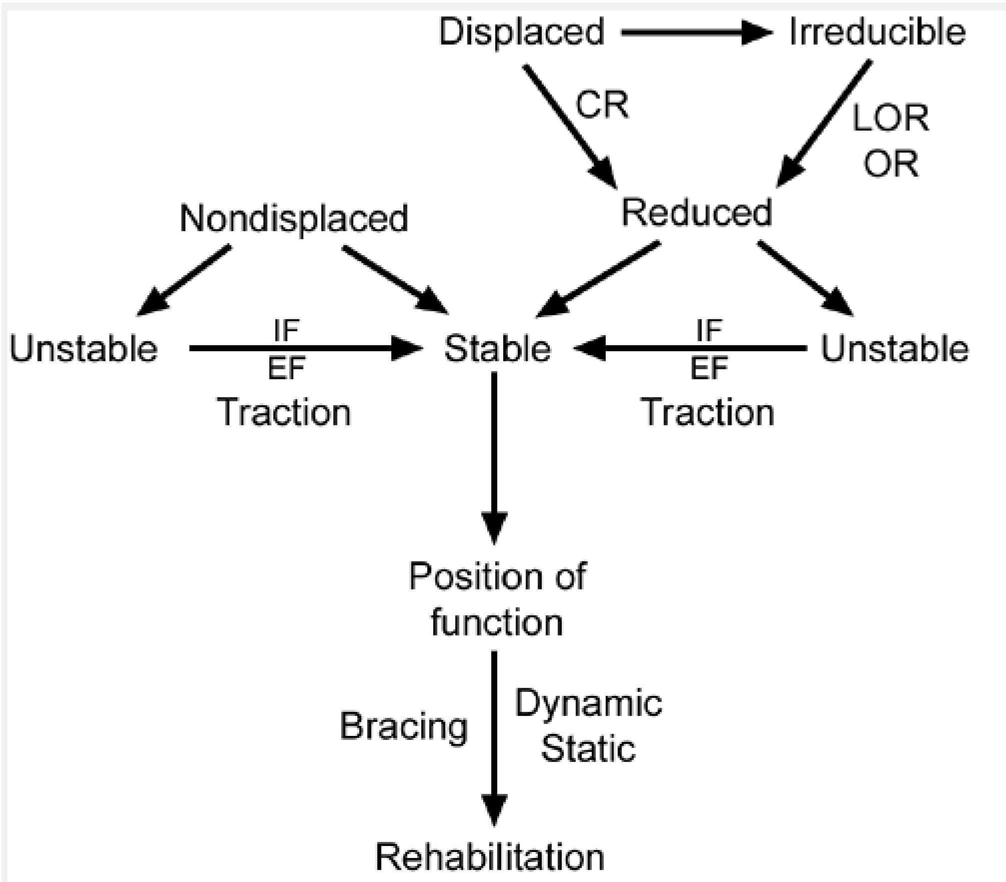


FIGURE 2. Hand fracture management algorithm. CR, closed reduction; EF, external fixation; IF, internal fixation; LOR, limited open reduction; OR, open reduction. (From Freeland AE, Sennett BJ. Phalangeal fractures. In: Peimer CA, ed. *Surgery of the hand and upper extremity.* New York: McGraw-Hill, 1996:923, with permission.)

The biomechanical stability of the fracture should be balanced with the blood supply of that site. In every situation, there is no alternate for arming the surgeon with the facts which allows him to select the methods and also correlate with his skills and to the every individual patient's unique circumstance. Hand fracture management is usually a combination of science of management plan and the art of management.

3.4.3 CLINICAL EXAMINATION

"Hand fractures can be complicated by stiffness from overtreatment, deformity from no treatment, and both deformity and stiffness from poor treatment"- Swanson [11]

While examining the patient, if he is possible to actively move the fractured finger by 50% of range of motion with out pain, the fracture is considered as functionally stable fracture. The X rays of the fracture shows minimum angulation and displacement in two planes, the fracture is considered radiologically stable. If the fracture cannot be reduced or after reduction it cannot be maintained in an anatomical position without K wire fixation when the hand is placed in functional position that fracture is considered to be an unstable one [12] .

The four factors that determining the stability are [13]

"External force.

Fracture configuration or personality.

Integrity of soft tissue including periosteal sleeve.

Muscle imbalance".

"Fracture involving the head of the phalanx is classified into 3 types, that is undisplaced, unstable unicondylar and bicondylar or comminuted[14]". These fractures are easily missed and needs AP, lateral and oblique views for careful assessment. Most of the fractures are unstable even if the fracture is undisplaced. This patients needs CRIF or ORIF with wires or screws.[15]

Fracture dislocation or subluxation of the Proximal inter phalangeal joint is more commonly occur on the dorsal side and rarely occur on the volar side. “Stability of the fracture dislocation depends on the size of the volar basal fragment of the middle phalanx”.[16]

Dynamic external fixation may have to be used in severe comminuted injuries, which is described by Suzuki[17] or one of the dynamic external fixator modifications[18]. Volar Fracture subluxation or dislocation which occurs in the volar aspect leading to button hole deformity which is a less common problem to occur. If it is encountered, it should be treated with closed reduction or open reduction to maintain the function and the articular congruity.

3.5 MANAGEMENT

3.5.1 CLOSED FRACTURES

Non operative Treatment of **Undisplaced Fractures**

The most of closed phalangeal shaft fractures are minimally displaced or undisplaced and foun to be stable; that is, they do not lose their reduction during active digital motion or spontaneously

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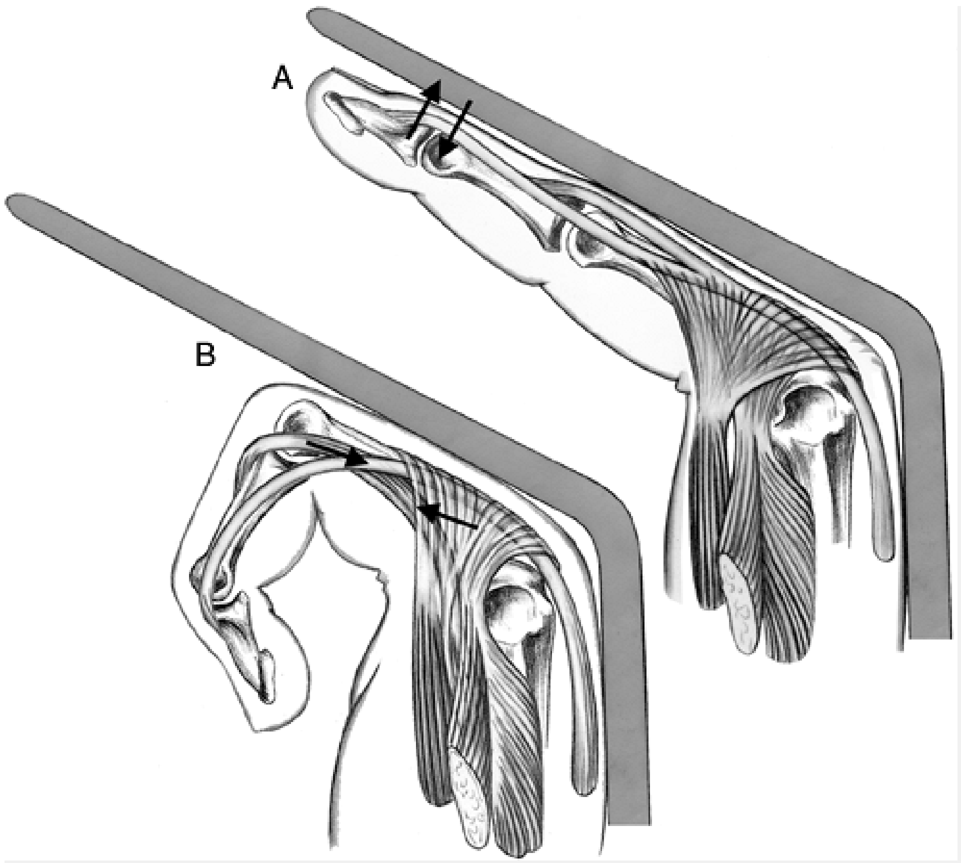


FIGURE 3. A dorsal functional hand-fracture brace **(A)** allows the patient to perceive full extension. Reduced fracture interstices contribute to stability. The extensor mechanism acts as a tension band that simultaneously compresses the fracture (*arrows*) during finger flexion and allows adjacent joint motion and tendon excursion **(B)**. (From Freeland AE, Jabaley ME. Hand and wrist fractures. In: Cohen M, ed. *Mastery of plastic and reconstructive surgery*. Boston: Little, Brown and Company, 1994:1509, with permission.)

This stability will be due to their inherent position of fractured fragments (transverse or short oblique) or additional periosteal support, or both. Splinting to an adjacent normal finger or buddy strapping is sufficient treatment in a compliant patient.

In patients with long oblique fractures, who require additional protection, are treated with short arm splint. Fingers should be kept in functional position which minimizes the risk of joint contracture, the interphalangeal joints at 0 - 15 degrees of flexion and the metacarpophalangeal joint at 50 - 70 degrees of flexion shich will in turn allows relaxation of the intrinsic muscles, and also increasing the balance at the fracture site.

Early, active range-of-motion exercises are started at 4.0 weeks in patients who are in static splints.But the excercises may be started at any time in patients, managed with buddy splints. In case of dynamic splinting, functional position is very effective which permits active flexion of the Inter phalangeal joints and which facilitates the extensor mechanism which act as a tension band over the proximal phalanx [19]. Active motion which in turn stimulates the periosteal callous formation and also shows improvement in digital motion. The fracture will be monitored radiographically for position, alignment, and healing.

3.5.2 Non operative treatment of displaced fractures

“Minimally displaced fracture has the displacement within one or more of the following x-ray parameters

- Less than 25 degrees of palmar angulation in sagittal plane,
- Less than 15 degrees of angulation in coronal plane,

- Less than 4 mm of shortening of finger
- Less than 10 degrees of rotation of finger"

The finger must be flexed within 1 cm of the distal palmar crease, and have no more than 30-degrees of extensor lag, and it should not be overlap on an adjacent digit while flexing digit. This guideline is considered to be approximate rather than absolute. But there are exceptions and individual circumstances will occur in some cases.

Finger block with local anaesthesia help the operating surgeon to determine the patients who are all meet these criteria's. Patients who meet those criteria's and whose fractures are stable before or after the reduction, these types of fractures are treated by closed methods without operative fixation.

"If a simple proximal phalangeal shaft fracture of stable configuration, it may be transverse or short oblique is angulated it may be usually palmar angulation in the sagittal plane and it may be otherwise undisplaced, there is an intact periosteal hinge which is dorsally opposite to the angulation. This fracture is usually occur in the proximal one-third of the phalanx. Manipulative reduction is successful. The fracture may be treated similarly to its undisplaced or minimally displaced counterpart" [19, 20].

3.5.3 Operative treatment of Displaced Fractures

Articular fractures:

Condylar fractures classified into three categories.

Type I - stable fractures without displacement

Type II - unicondylar, unstable fractures

Type III - fractures are bicondylar or comminuted.

In addition to lateral and antero posterior radiographs (Figure 8.22), oblique radiographs are important to visualize the fracture geometry clearly and assess stability and displacement better.

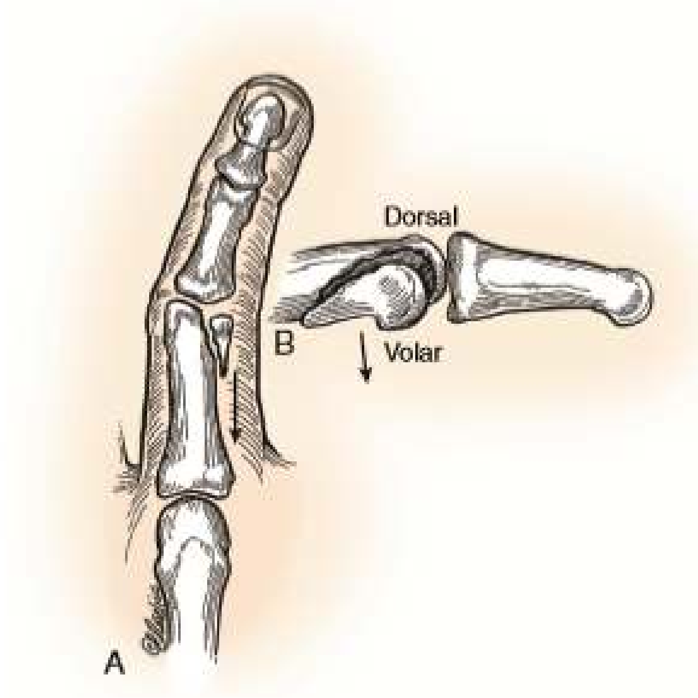


Figure 8.22 A, Anteroposterior view of condylar fracture. Note articular step-off. **B,** Lateral view. Note volar displacement of condylar fragment. *(Copyright Elizabeth Martin.)*

Weiss and Hastings developed a classification for unicondylar fractures of the proximal phalanx [15] and he made two important observations.

First, initially non displaced fractures are inherently unstable. Non operative management needs extremely close follow-up.

Second, fixation with a single Kirschner pin is inadequate.

Displaced unicondylar fractures require ORIF. Two most popular techniques of fixation are Kirschner pins and lag screws. Of these, multiple Kirschner pins gave the best final range of motion at PIP joint. Postoperatively, a 20- to 30-degree PIP extensor lag will occur frequently.Correction of this problem will be obtained by dynamic extension splinting.

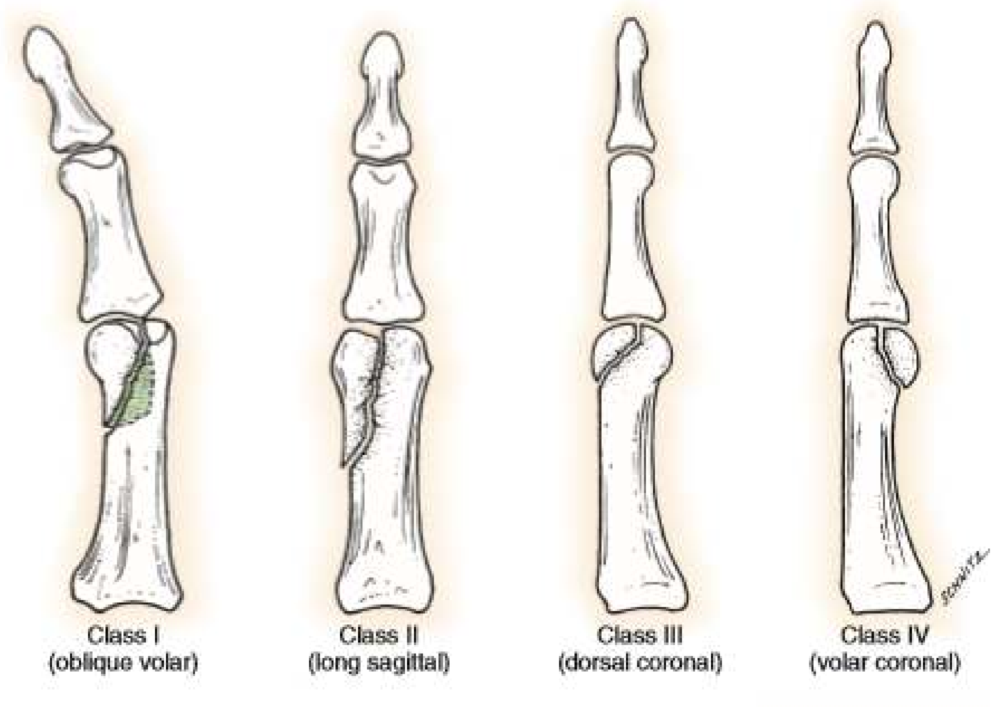


Figure 8.23 Weiss-Hastings classification of unicondylar fractures of proximal phalanx. These fractures are nearly all unstable and nearly always require operative fixation. *(From Weiss APC, Hastings HH: Distal unicondylar fractures of the proximal phalanx,* J Hand Surg [Am] *18:594-599,1993.)*

Comminuted intra-articular fractures and bicondylar fractures can be very difficult to fix. Buchler and Fischer used mini-condylar plate. PIP joint stiffness frequently occurs inspite of any fixation method.

Displaced unicondylar fractures are best managed by operative method. The fracture is exposed through either dorsal ulnar or dorsal radial longitudinal incision. The space between central tendon and the lateral band the joint is entered. Detachment of central tendon should be avoided which is attached to the dorsal base of the middle phalanx. Fracture hematoma is removed and takes care not to detach the condyle from its attachment to collateral ligament. The fracture is anatomically reduced with a bone tenaculum, and reduction is confirmed fluoroscopically. The condylar fragments are fixed with two parallel Kirschner pins (0.028-inch or 0.035-inch) which is drilled through the fragment into the intact bone. Inter fragmentary screw fixation was done with two 1.5-mm or 1.3-mm screws and can be used if the fracture fragment is three times of the external diameter of the screw. Lastly the dorsal extensor apparatus is reapproximated. Early active motion is initiated postoperatively, and the PIP joint splinted in extension to avoid extensor lag postoperatively. Kirschner wires are usually removed at 3 to 4 weeks. Screws usually not removed unless they are symptomatic. Although ORIF is the usual standard of care for the management of intercondylar fractures, closed reduction and percutaneous pin fixation may also be considered within 5 days from the injury. Using mini-C-arm, a pin is placed inside the condylar fragment which is used as a joystick to manipulate the fragment to its anatomic position.

Finger traction is helpful to assist in reduction and also to free the surgeon's hands for manipulating and fixing the fragment. The reduction is maintained with a bone tenaculum, and is verified after reduction by radiography. Fixation is secured with two or three appropriately sized Kirschner pins. Small cannulated screws are available for percutaneous management of these types of fractures. This technique has advantage of minimizing the soft tissue damage, but it can be very tedious and does not allow the direct visualization of fracture to verify anatomic reduction. One must be cautious that the joystick pin and the bone tenaculum, which do not inadvertently fragment the fractured condyle.

3.5.4 NON ARTICULAR FRACTURES

MANAGEMENT OF NECK FRACTURES

Neck fractures, subcondylar or subcapital fractures of the phalanges are uncommon in the adults, common in children[21] and can be usually managed in closed fashion by reduction and splinting or may be by percutaneous crossed Kirschner pins.

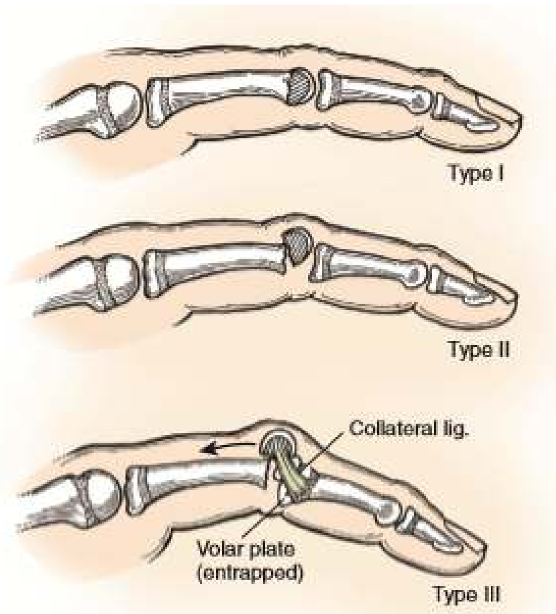


Figure 8.30 Classification of fractures of neck of proximal phalanx in a child. *Type I*: Nondisplaced fracture. *Type II*: Displaced with some bone to bone contact. *Type III*: Completely displaced, no bone to bone contact; may rotate 180 degrees. *(Modified from Al-Qattan MM: Phalangeal neck fractures in children: classification and outcome in 66 cases,* J Hand Surg [Br] *26:112-121, 2001. Redrawn by Elizabeth Martin.)*

SURGICAL MANAGEMENT OF SHAFT FRACTURES

Indications for fixation

When phalangeal shaft fractures are unstable and may require open reduction. If the deformity recurs after an initial closed reduction, internal fixation is indicated. Displaced oblique fractures and comminuted fractures are mostly unstable because of the position of fracture fragments and periosteal disruption. Periosteal injury and resulting instability will be equal to the amount of displacement of fracture. Amount of bone loss causes instability in open fractures. Internal fixation is preferable to external splinting in traumatized, systemically impaired, and older patients.

Reduction will be achieved and maintained by combining the most reliable and suitable for that situation. Stability may not be a rigid one, or does not require the use of the strong fixation choices. “The fixation method or the implant that is selected need to provide a threshold level of strength that are reliably holds the fracture securely, until it has been healed sufficiently that it is to be no longer implant dependent and also allows simultaneous early rehabilitation”

Surgical incision, which is accompanied by periosteal elevation, and in the area of flexor tendon sheaths, risk of scar formation and also the risk of devascularisation of fracture fragments. “The surgeons must be able to weigh the potential benefit of increased biomechanical stability of the fracture that will be gained through surgical incision against additional risk of the consequent digital stiffness and delayed healing”. This is true of late-presenting displaced fractures which are stable and demonstrate callous formation radiographically but there may be pain free and functional digit.

Operative treatment is to achieve more perfect reduction. But it also have the risk of double dose of soft tissue damage which will result in digital stiffness. This poor outcome is not fair than that achieved by accepting initial presentation.

CLOSED REDUCTION AND INTERNAL FIXATION

The majority of the fractures of displaced nature of the simple phalangeal shaft fractures are treated with percutaneous Kirschner wire fixation. The position of this type of fracture is difficult to monitor which is owing to overlap of the fingers in lateral x-ray. One or two intra medullary wires act as internal splints and these wires are reliably support the stability of transverse or short oblique fractures [22-24]. Fractures distal portion of phalangeal shaft, percutaneous Kirschner wires will be introduced, from distal to proximal in direction. This method provides more secure fixation of small distal fragment to the main fragmant of the phalanx. This technique protects the growth plate of proximal phalanx in children.

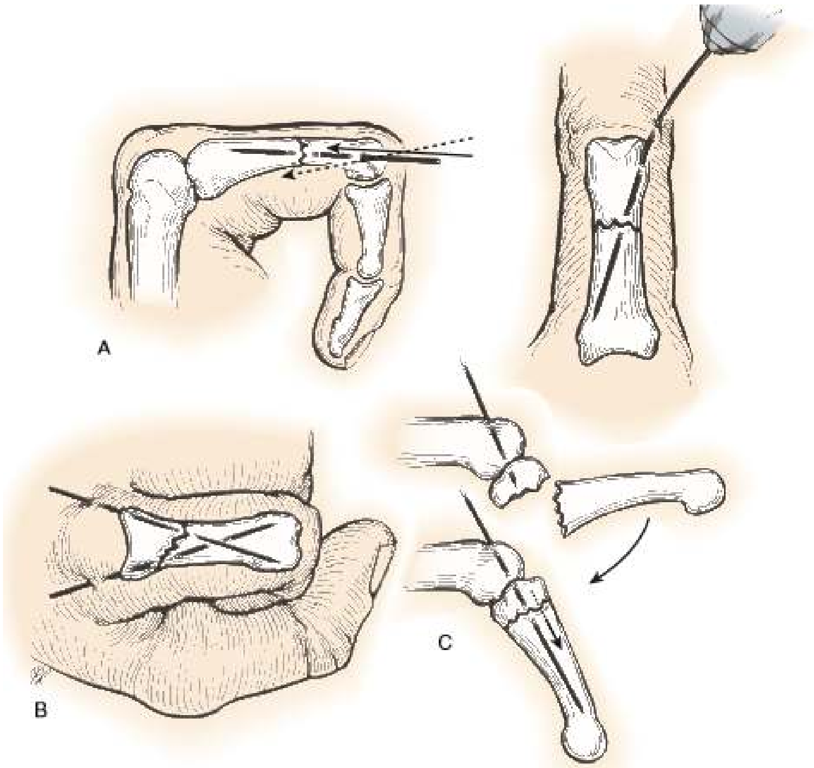


Figure 8.33 Three methods of closed reduction and percutaneous pinning of transverse phalangeal fracture. A, Fracture is reduced in 90-90 fixed position, and Kirschner wire is introduced in retrocondylar fossa of proximal phalanx. Slight reverse bowing of pin while it is being drilled is often necessary. Normal dorsal bow of proximal phalanx necessitates slight dorsal direction of pin. B, Alternative method of percutaneous pinning for fractures of proximal half of shaft. C, Technique for closed reduction and percutaneous pin fixation useful for extra-articular fractures near base of proximal phalanx. This method requires plaster immobilization for 3 weeks because Kirschner pin crosses MP joint.

Displaced, simple oblique fractures are reduced by closed manipulation; and they are stabilized by transcutaneous pinning or mini screws. Smooth Kirschner wires are most often the best implant choice. These wires splint the fractures but do not compress fractures.

3.5.5 OPEN REDUCTION AND INTERNAL FIXATION OF PHALANGEAL FRACTURES

Incisions and Approaches

Fractures in phalangeal shaft are approached through a dorsal incision. The extensor tendon is divided centrally or between the central and lateral bands. Pins are inserted percutaneously, after the fracture reduction, or by retrograde method through any one fragment, before reduction. Fracture is then reduced, and pins are driven through the fracture site and fixed. This is an effective technique in absence of x-ray capabilities [25].

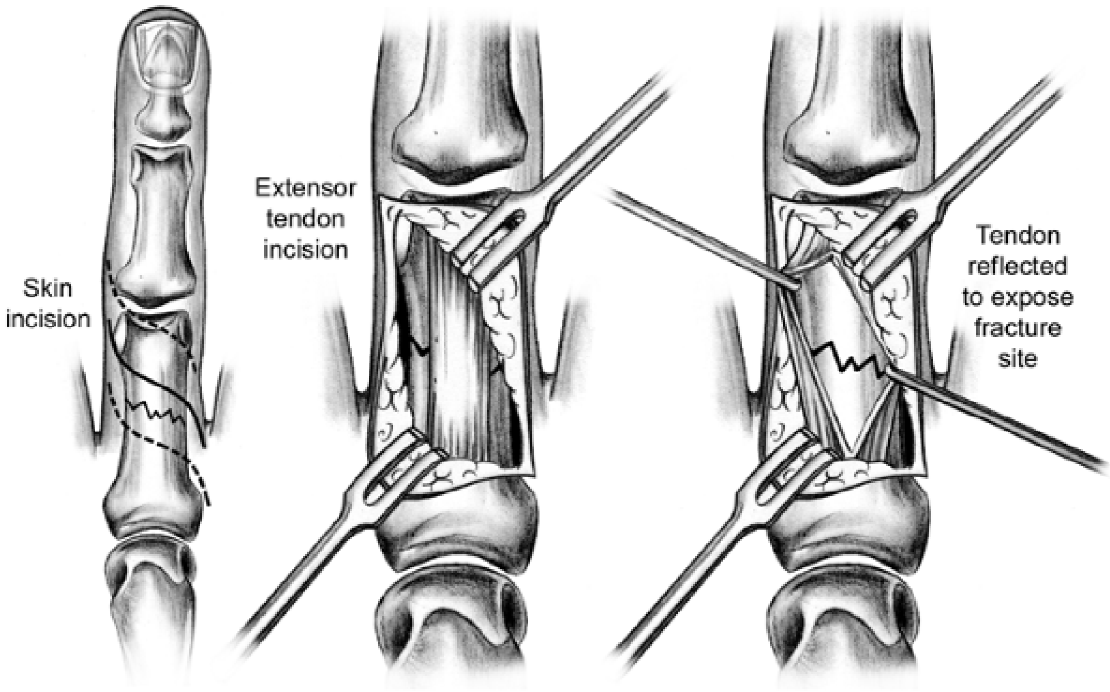


FIGURE 9. A dorsal incision **(A)** may be centered over a phalangeal fracture and patterned to avoid direct alignment with a midline extensor tendon incision **(B)** that is used to expose the fracture **(C)**. (From Pratt DR. Exposing fractures of the proximal phalanx of the finger longitudinally through the dorsal apparatus of the finger. *Clin Orthop* 1959;15:24, with permission.)

A midaxial incision is preferable in juxta articular transverse or short oblique fractures of shaft. Lateral band and the oblique fibers are excised unilaterally under the mid axial incision. This will allows direct implant application to fractured phalanx and decreases the chance of adhesions and the chance of irritation under the extensor apparatus. This prevents adhesion, which may be occur between a dorsally applied mini plate with the extensor apparatus and restrict the finger flexion and extension in the extremes of movement. Distally, mid axial approach which minimizes risk of the injury to the central slip during surgery and minimise subsequent boutonnière deformity.

"In the clinical setting, mini screws have been shown to provide stable fracture fixation and little interference with tendon gliding"[26]. Mini screws may be used in unstable long oblique uniplanar or spiral fractures of shaft of proximal phalanx. Oblique fractures are of two times the diameter of the adjacent bone, so that at least two screws may be inserted. The self-tapping design which facilitates the application of mini screws [27].

"Mini plates used selectively on phalanges" [28, 29]. They are better choice in closed transverse fractures or closed oblique fractures that require open reduction and also good in open injuries. Mini plates are useful with fracture comminution or fracture with bone loss. Straight mini plates are also suitable for diaphyseal fractures, and mini condylar plates are also suitable for fractures near articular surface. Mini condylar plates which are applied in the lateral aspect is strongly resisting the apex volar angulatory forces which is usually occuring in these fractures[30]. Clinical results from use of mini condylar plates in phalangeal periarticular fractures are comparable to or better than those in other methods of treatment.

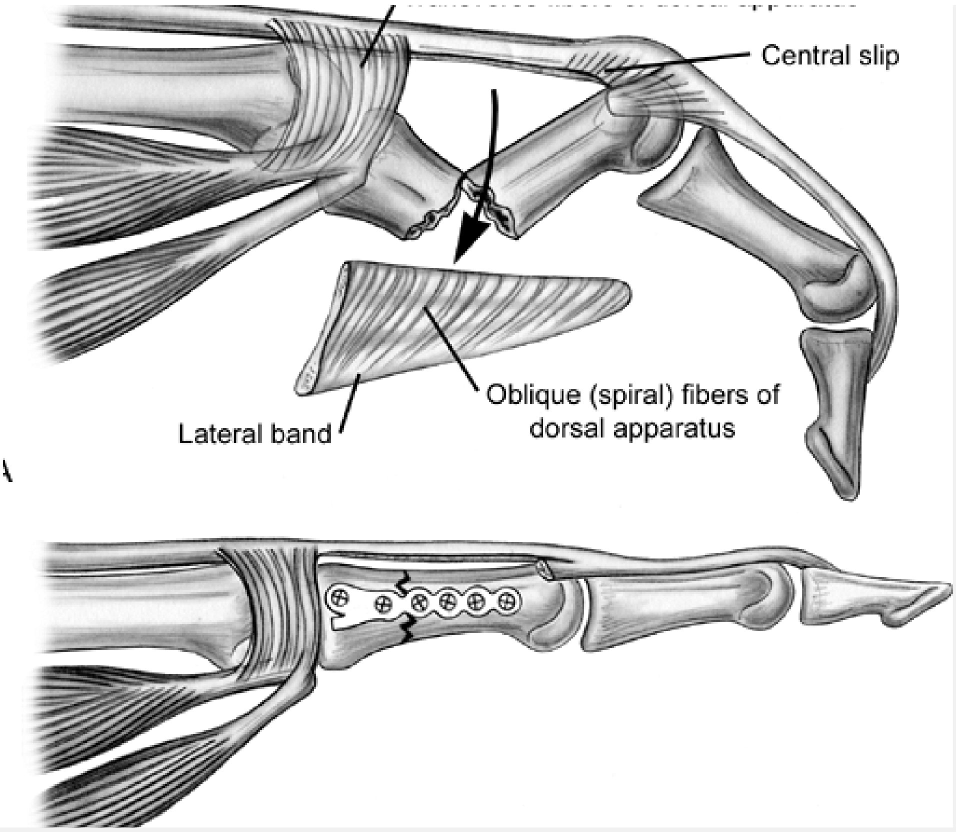


FIGURE 12. A: The oblique spiral fibers and adjacent lateral band are excised as a triangle (*arrow*). **B:** A mini condylar plate has been applied laterally for fracture stabilization. (From Freeland AE, Sud V, Lindley SG. Unilateral intrinsic resection of the lateral band and oblique fibers of the metacarpophalangeal joint for proximal phalanx fractures. *Tech Hand Upper Extrem Surg* 2001;5:86–87, with permission.)

3.5.6 EXTERNAL FIXATION

Surgeons recommend the general management of the unstable fractures of phalanx with the external fixation devices [31-34]. Mini external fixators are used for stabilizing the unstable fractures. External fixation is used in the treatment of the open fractures of phalangeal shaft with the severe comminution, and the bone loss. They are also helpful in initial fixation of the severe open hand fractures with the significant bone destruction and soft tissue destruction. These external fixators are maintained for definitive fracture management or sometimes replaced by the internal fixation usually Mini plates are usually used for fixation in this situation, at the time of the bone grafting and wound closure or coverage.

The refinement of the external fixators allows stabilization of the fractures, and also permitting relatively full range of motion of the adjacent digits. Mid lateral insertions is the preferred method. But in case of fracture involving the proximal aspect of proximal phalanx, dorsolateral insertion is used owing to space constraints. The fracture is fixed with minimum of two pins on either side. Both cortices must be engaged by the each pin. In addition to that the adjunctive independent additional Kirschner wire insertion is used.

"Advantages of the mini external fixator in finger fractures include no surgical exposure of the fracture site, the adequate stability, and ability to manipulate the inadequately reduced or secondarily displaced fracture. Transfixion of part of extensor mechanism is often unavoidable in proximal phalanx, and the functional results of external fixation at the phalangeal level are less reliable than at the metacarpal level".

3.5.7 OPEN FRACTURES

In addition to fracture, the open fractures are present with additional problem of wound [35, 36]. The fracture is stabilized by using the principles that are outlined previously. Wound must be closed primarily or covered with graft or flap. Wound cleaning is the most important part of treatment modality. Simple wounds are usually clean, and simple fractures are definitively fixed during the initial surgery. Wound closure also done at the same time.

Before proceeding with further reconstruction, Complex wounds may require a second look to confirm the cleanliness at 2 to 3 days after the initial surgery. Open fractures require Extension of the wound by incision may be needed to apply the adequate fixation in case of open fractures, Bone graft or bone graft substitute are used to fill the bone gap. If the fracture will need to be managed with the open fracture reduction and internal fixation, the repaired digits require more accelerated and severe intense mobilization for good functional recovery. In case of severe injuries, secure fixation and early mobilisation will help to reduce the risk of contracture of the joints and the tendon adhesions.

3.5.8 POST OPERATIVE PERIOD

First three days of post operative period, patient treated with parental antibiotics followed by oral antibiotics for 5-7 days. After surgery, active finger and wrist movements were encouraged. Check X rays were taken on the next day of surgery. On tenth post operative day the sutures are removed.

The patients were reviewed every fifteen days for the first 2 months, and then monthly once for next 4 months. Repeat radiographs were taken at 4 to 6 weeks after surgery look for fracture union. External hardware was removed after confirming the fracture union. Active finger movements are encouraged. During every visit any improvement in the range of movements (ROM) were noted. Complications like pain, tenderness, grip strength, pinch strength, and TAM and untoward complication of the treatment were also noted. Patient followed up for 12 months after surgery.

3.5.9 REHABILITATION

Elevation is continued until the dependent swelling is no longer a problem. A buddy, static, or functional splint applied. Wrist, hand, and digits are functionally positioned. Patients treated with buddy splint or functional splints, midrange digital motion initiated within the first 24 hours after the surgery. In operated patients, the dressing is changed 3 to 5 days after the surgery, and a light flexible dressing is applied. A buddy splint is used in concert with a static or functional splint to help to mobilize and to protect the injured finger. The remaining digits are left free and functional. As pain and the swelling recede, the digital range-of-motion exercises are gently progressed, until the full and unrestricted motion recovered, or until no further motion can be gained.

3.5.10 FOLLOW UP

Range of motion

Number of ways is available to determine the range of motion. Both the active range of motion and the passive range of motion (PROM) will be recorded during follow up. The active range of motion of the joint is dependent on the passive capacity of that joint. This is very important in the follow up whether the treatment measures are achieving desired result. Range of motion must be recorded to compare the preoperative and postoperative results.

Active range of motion (AROM)

Arc of motion which is achieved when the muscles that control a joint are used to move the joint is known as active range of motion. Causes for the limited motion will be the loss of the tendon continuity, the tendon adhesion to adjacent structures, the tendon inflammation, and the tendon constriction.

Passive range of motion (PROM)

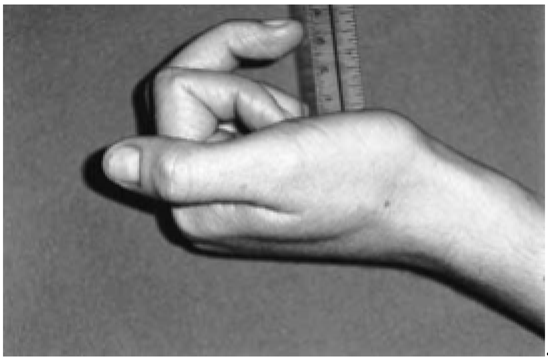
The arc of motion is achieved when external force, like some ones hand, is used to move joint is known as PROM. Factors that influence the joint's passive range of motion include the disruption of articular surface and fibrosis of the capsule.

Total active range of motion (TAROM)

TAROM which is known as total flexion range of a digit when its three joints are flexed at the same time and if there is any of extension deficit over the three digital joints it will be subtracted.

Total passive range of motion (TPROM)

Same as that of total active range of motion except the external force that is used to move digit.



A ruler is used to assess the composite finger flexion which measures the distance from the pulp of the finger to the palm

Goniometer for measuring the joint motion

Goniometer is used to assess the joint range of motion. The size of the goniometer depends on the size of the joint to be measured. Wrist and forearm motion is measured using the goniometer size of 15 cm length. 4–6 cm arm length is used to measure the digital range of motion.

To optimize accuracy when assessing the range of motion, the contact of the goniometer arms with skin should be as intimate as possible.

Grip strength measurement

Power grip

Jammer dynamometer is used to measure the power grip strength. Five handle positions are there in this dynamometer to measure the power grip, each position influences strength of the grip. Strongest grip strength position is the third one followed by second, fourth, fifth and first. The position during the measurement of grip strength is as follows: shoulder in adduction, elbow is in flexion of 90 degrees, forearm is in neutral rotation, wrist is positioned between 0 to 30 degrees of extension and with slight deviation in the ulnar side.

Pinch grip strength

Pinch gauge is used to assess the pinch grip strength .This is measured in three ways. (1) tip-to-tip pinch which is measured between thumb and index finger. This is the weakest pinch grip. (2) lateral pinch is measured where the thumb is clasped against the radial side of the index finger. This is the strongest pinch grip and (3) three-jaw chuck where the pulp of the thumb is pinched against pulps of the index and the middle fingers. Three readings are taken and the average reading is recorded.

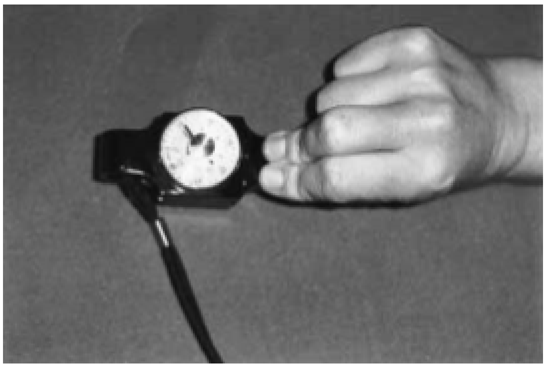


Figure 1.17 A pinch gauge is used to assess the three pinch grip positions:

3.5.11 COMPLICATIONS

Algorithm

The principles and algorithm for managing complications of phalangeal fractures are similar. If principles failed initially, they are to be reapplied. Deformity or the malunion must be corrected. Stable fixation becomes an essential, so that mini plate fixation is instrumental in achieving bone healing while allowing the simultaneous rehabilitation. Fracture compression or bone grafting of the defects plays an important role in recovery.

Stiffness

Stiffness is most frequent complication of phalangeal shaft fractures. Joint capsular contracture and as well as the extensor and flexor tendon adhesions, may occur [37]. Late presentations persistance of the deformity, excessive immobilization (for a duration of more than 4 weeks), immobilization in the inappropriate positions, comminuted fractures, crush, complex wounding, the mini plate application, the multiple digit fractures, or an inadequate rehabilitation program may be individually and collectively cause or contribute to the stiffness.

Extension contractures of the metacarpophalangeal joints and the flexion contractures of proximal interphalangeal joints are the most common patterns of the finger joint stiffness. Aggressive therapy that includes the active, active-assisted, and passive stretching exercises and the dynamic splinting may overcome mild to moderate degrees of the stiffness and may be pursued as long as 3 to 6 months after the injury and before considering remedial surgery. Recalcitrant contractures of metacarpophalangeal joint may require the dorsal capsulectomy, whereas the proximal interphalangeal joint contractures may respond to the release of the checkrein ligaments of the volar plate.

The risk of flexor tendon adhesion are prevented by restoring continuity of bony surface of flexor canal by accurate fracture reduction and by initiating the early active motion exercises and continuing them during healing process. Flexor tendon adherence identified by limited active motion in the presence of the more complete passive range of motion. Extensor tendon adhesions are typically present as an extensor lag in absence of a fixed joint contracture but also prevent full flexion.

When tendon adhesions are confined to proximal phalangeal shaft and do not respond adequately to the therapy, tenolysis will improve but usually does not eliminate the residual stiffness. Results are less successful and less reliable when tenolysis and the release of joint contractures will be performed simultaneously.

Non union

Non union is likely to occur with the comminuted than with simple fractures. This is true when Kirschner wire fixation is used [38]. Transverse or short oblique fractures are failed to unite if they are distracted by intramedullary fixation.

Correction of deformity and stable mini plate fixation is usually necessary for successful resolution of the nonunion. Hypertrophic defects require only compression, but non unions with bony defects or atrophy must be treated with bone grafting or bone graft substitutes

Mal unions

Mal union may be seen in the late-presenting fractures or may be due to the persistent deformity. Many minor deformities are seen on x-ray are not clinically apparent. If a visible clinical deformity is present, it needs to be corrected only if it is causing substantial discomfort or functional impairment that is problematic to patient. Corrective osteotomy will require extensive dissection [39, 40]. Healing may be prolonged and unreliable owing to the surgical devascularization of the bone. Consequently, mini plate fixation is usually required to assure adequate stability for the healing and the intensive rehabilitation. Rotational deformities of more than 25 degrees are corrected by metacarpal rotational osteotomy, which diminishes risk of postoperative finger stiffness [41].

Infection

The abundant vascularity of the hand make fracture less susceptible to infection, with rates varying between 6% and 11%. Infection rates are significantly increased in presence of gross wound contamination, extensive soft tissue and skeletal injury, systemic illness, or delay in treatment that exceeds 24 hours. Delays in the treatment of as long as 12 hours do not increase incidence of infection nor do they affect outcome. Delayed wound closure is recommended for open injuries with gross contamination.

Implant Complications

Kirschner wire fixation remains the most commonly used method of fixation for hand fractures. Transverse and intra medullary pinning have relatively low incidence of complications, which includes loosening, migration, tendon trans fixation, pin-site infections, irritation of skin, loss of fracture reduction, and symptomatic non-union.

In a review of 422 pins, were used to stabilize hand and wrist fractures in 137 patients, complications are occurred in 11% of the pins and in 18% of the patients; 69% of these complications occurred in phalanges. Poor pin placement and lack of the patient compliance were most often associated with these complications. In most cases, poor pin placement was not recognized at the time of insertion and discovered on follow-up. So pin placement should be confirmed by x-ray at the time of insertion. Pin loosening was developed at a mean of 8 weeks, whereas pin tract infections occurred at a mean of 10 weeks. Pins should be removed in timely manner, as soon as bony healing allows (3 to 6 weeks). Stiffness is the most common complication of mini screw and plate fixation. Implant failure is very rare.

4 MATERIALS AND METHODS

The study was conducted in Coimbatore Medical College Hospital during the period of JUNE 2013 to January 2015. This is a non randomized descriptive prospective study.

4.1 Selection of patients:

Inclusion criteria:

1. All acute and delayed presentation of closed proximal phalangeal fracture patients attending plastic surgery OPD by themselves or being referred from trauma ward or other specialties in Coimbatore Medical College Hospital were the source of cases for the patient.
2. Cases of age group where they will be able to make an assessment outcome by themselves were included.
3. Fracture involving only one finger in the hand is selected for the treatment.

Exclusion criteria:

1. Patients with open proximal phalangeal fractures and who cannot make assessment of their management outcome were excluded.
2. Patients with fracture involving multiple fingers are excluded.

4.2 CLINICAL ASSESSMENT:

HISTORY OF THE PATIENT:

On first consultation name, age, and sex recorded in the patients with proximal phalangeal fractures. History of mode of injury, duration, pain and previous treatment received were recorded.

PHYSICAL EXAMINATION:

To diagnose proximal phalangeal fractures effectively, the mechanism of injury and the force of the trauma should be queried in the initial examination. After careful inspection, identification of the most painful area should be done by palpation. The active and passive ranges of motion (ROM) of the joints, existence of a possible capsule and ligament instability should be searched. The stability of the joint can be assessed with the stress test, which is performed while the finger is in flexion and extension. In X-ray examination, three views are essential: antero posterior, lateral and 45° oblique. Articular fractures are often not seen without the oblique views. Anatomically, proximal phalangeal fractures can be divided into four categories, fracture involving condyle, neck, shaft, and base. Other parameters important for proximal phalangeal fractures are:

A. Displacement of the fracture.

B. Stability of the fracture.

C. Involvement of the joints.

D. Type of the fracture, such as oblique, spiral, transverse or comminuted.

Stable and non displaced proximal phalangeal fractures can be effectively managed by protective splinting and early controlled mobilization. Although three weeks of immobilization is accepted as safe, each patient and fracture type has its own characteristics. Each fracture, therefore, should be assessed individually.

Unstable and non displaced proximal phalangeal fractures should be managed with fixation. Proximal phalangeal fractures may angulate volarly or dorsally due to localization of the fracture and interactions with the tendons and interosseous and lumbrical muscles. Angulated fractures are considered as unstable and require open reduction and fixation.

Non displaced intra articular proximal phalangeal fractures are highly unstable and susceptible to displacement. Those fractures are occasionally misdiagnosed as sprain, and early mobilization may cause their displacement. Bicondylar fractures are almost always multiple fractures and require open reduction as with unicondylar fracture treatment.

Multiple fractures in proximal interphalangeal (PIP) joints are known as pilon fractures. If open reduction and fixation is not possible in such multiple fracture cases, traction-closed reduction or dynamic external fixation devices can be options. Restoration of movement is usually unpredictable in such cases. Primary arthrodesis or osteosynthesis applications may cause unexpected results, such as excessive shortening of the finger. Since arthrodesis is already possible as a secondary procedure, restoration of the primary structure should be preferential.

Dynamic external fixation devices are hinged and span the PIP joint to allow early protected ROM while maintaining reduction of the joint. There is a consensus about treating displaced proximal phalangeal fractures with open reduction and internal fixation. Generally, 1 mm or 1.2 mm K-wires used for fixation.

4.3 CONSERVATIVE METHOD

The angulated or displaced, fractures were reduced under digital block. Longitudinal traction was given by using the thumb of the surgeon as a fulcrum to reduce the fracture. Metacarpophalangeal joint was flexed maximally to stabilize the proximal fragment and the distal fragment was flexed to correct the volar angulation. Rotations were checked with reference to the curvature of the fingernails. On achieving satisfactory reduction, confirmed with check X-ray the digit was splinted with POP in JAMES POSITION.

James Position:

- Wrist 30 deg extension
- MP 70 deg flexion - here the collateral lig. are stretched to max and therefore do not become stiff;
- PIP < 20 deg flexion - these will become stiff in flexion, however, it is imperative that PIP joints be immobilized in sufficient flexion to correct this volar angulation;
- DIP 10 deg flexion

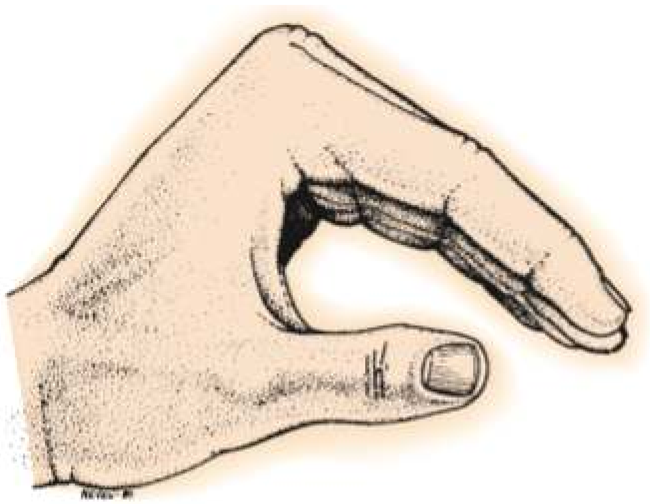


Figure 8.32 Safe or intrinsic-plus position of James for hand immobilization.

4.4 OPERATIVE METHOD

Patients were operated under axillary block, wrist block or digital block. Fixations were achieved with 1 mm percutaneous intramedullary K-wires. Two K-wires were used for fixation when one K-wire did not provide enough stability. Dorsal incision is usually preferred when the fracture is not adequately exposed and mid lateral and lazy ‘s’ incision also used. The fracture line is exposed without damaging the connections of the central slip of the extensor tendon. Any ligamentous and soft tissue attachments in the fracture fragments should be preserved, if possible. Fracture lines are fixated with one or multiple Kirschner wires or screws. When possible, the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints were held in nearly full extension during the fixation to prevent the volar plate and collateral ligament contracture.

‘K’ wires are versatile, easily available, cheap, implant which can be used either percutaneously or by open methods [15],[16]. It is available as smooth or threaded pins in different sizes and also with different tips (trocar tip and bayonet tip). K wires can be passed by open method or closed method from one end (fragment) of the bone (proximal or distal) across the fracture site into the other end (distal or proximal) otherwise called centripetal. It can also be passed by either closed or open method through the fracture site first into (proximal or distal) and later after obtaining reduction into the other fragment (distal or proximal) otherwise called as centrifugal method. These terminologies will avoid confusing terms like antegrade method and retrodrade method. The exact method of passage of K wire in terms of direction can be radioulnar, ulnoradial or central depending on the fracture anatomy. But it is desirable to approach the fracture site by the K wire at an angle close to 90°. This approaching angle of the K wire should be preferably more than 45° in all cases. Though any fracture configuration can be effectively managed with K wires with or without supplemental SS wire, K wires do have the limitations, because it is non rigid and also cause pin loosening, pin tract infection, tendon impalement and sometimes neurovascular injury.

FOLLOW UP

Since joint stiffness occurs after a three-week immobilization period, K-wires are removed at the end of the 3rd week. Radiographs are also used for evaluation of bone healing in the postoperative 3rd week. The removal of the K-wire is delayed if adequate bone healing is not observed in the follow-up radiographs. In our series, K-wires were removed between 3-4 weeks. Physiotherapy was started just after the removal of the K-wires.

4.5 EXTERNAL FIXATION:

External fixation has a definite role in compound fractures and badly comminuted closed intra-articular fracture dislocations. Ideally a digit with skeletal injury should be immobilised for up to three-four weeks to have an acceptable functional outcome. Dynamic spanning fixator which can achieve and also maintain reduction and yet allow mobilisation makes it an ideal choice for pilon fracture of the base of the phalanges with or without subluxation or dislocation.

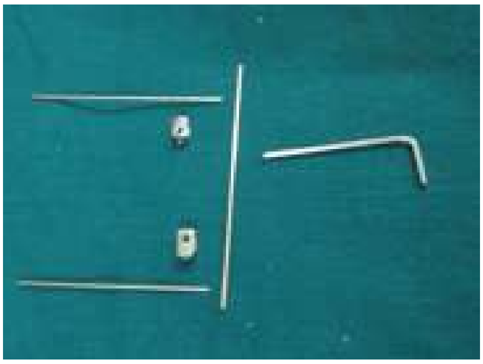
INSTRUMENTATION

- Hand drill (Electrical, pneumatic or mechanical).
- T-Handle with chuck.

- Wire cutters
- Allen keys 2.5 mm and 3 mm
- Rod benders.

BASIC COMPONENTS

- Krishner wires - 1.2mm, 1.5 mm and 2.0 mm K-wires with 15 cm and 20 cm length.
- Connecting rods.
- Distraction and compression external fixator screws.



The fracture to be treated is reduced. Instruments and basic components needed for external fixation is very cheap and easily available.

The displaced and comminuted fractures are treated using Mini external fixator. Two 2-mm pins were inserted dorsolaterally, proximal and distal to the fracture after predrilling done bicortically with a 1.5-mm drill bit. After reducing the fractures ,the connecting rods and swivel clamps were tightened.

4.6 POST OPERATIVE MANAGEMENT

A splint was used for all patients and elevation was recommended. Postoperatively, follow-up radiographs were taken immediately to verify adequate reduction. Usually, intravenous antibiotic was administered postoperatively for three days followed by oral antibiotics for seven days. When placing the splint, the PIP joints are held in nearly full extension to prevent the collateral ligament and volar plate contracture that occurs in flexion. Suture removal done at 10^{th} post operative day. The K-wire is removed 3-4 weeks postoperatively and the mobilization starts under the observation of a physiotherapist.

4.7 FOLLOW UP

Following parameters were considered during follow up

A. Active range of movement in MCP joint

(Flexion – Extension = 30 degree - 0 - 90 degree)

B. Active range of movement in PIP joint

(Flexion – Extension = 0 – 100 degree)

C. Active range of movement in DIP joint.

(Flexion – Extension = 0 – 70 degree)

D. The function of the hand and the injured finger (grip strength).

(Varies depending on the age of the patient, amount of weight used

E. Pinch strength

F. Total active range of motion.

5 OBSERVATION AND RESULTS

A total of 50 patients included in the study.

5.1 Sex incidence

Sex	Male	Female
	44	6

Table 1 Sex Incidence

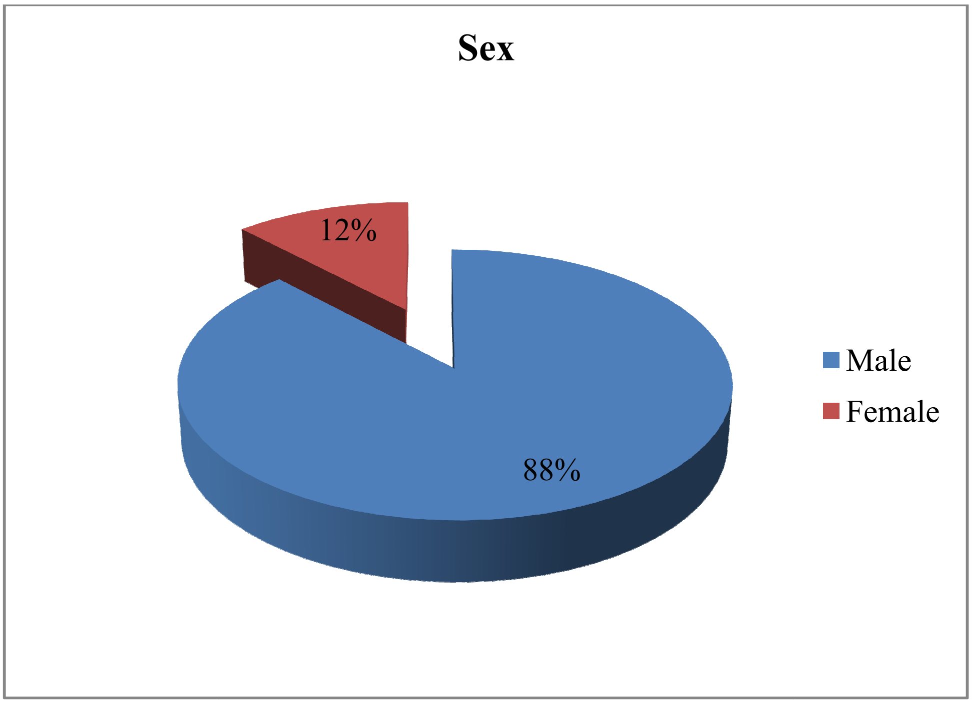


Figure 1 Sex Incidence

5.2 Age Incidence

Age Group	15-25	26-35	36-45	46-55
	13	15	14	8

Table 2 Age incidence

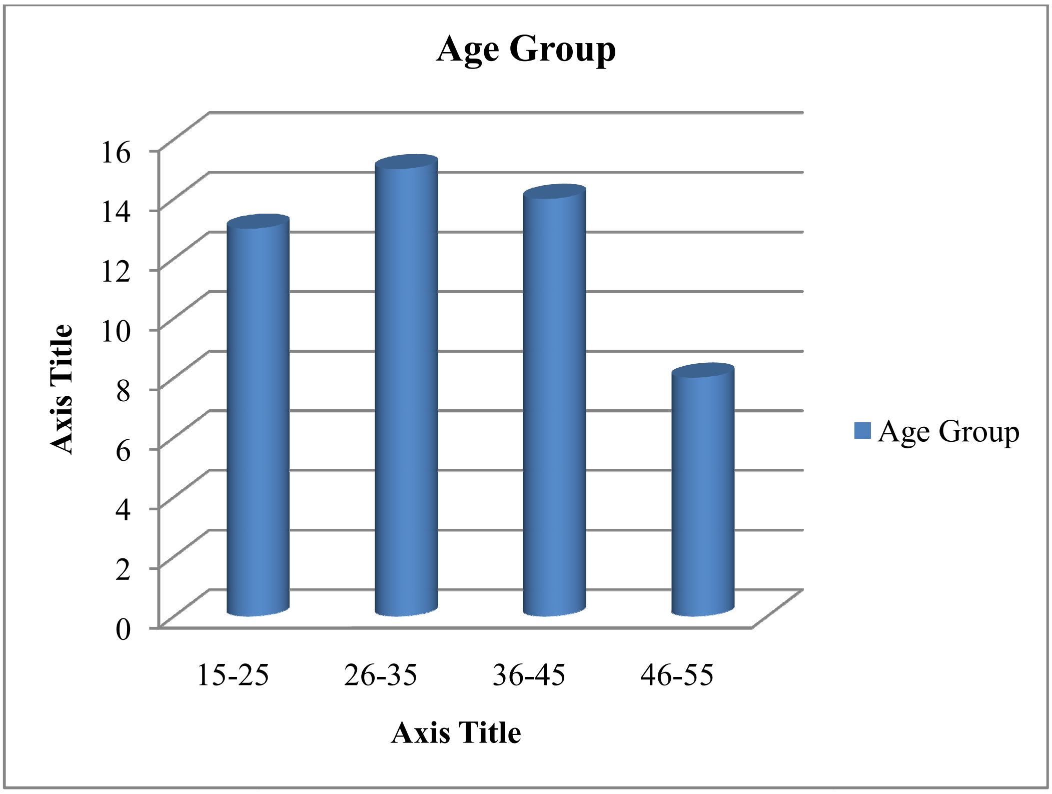


Figure 2 Age incidence

5.3 Mode of Injury

Mode of Injury	Fall	RTA	Assault	Blast Injury
	17	22	8	3

Table 3 Mode of injury

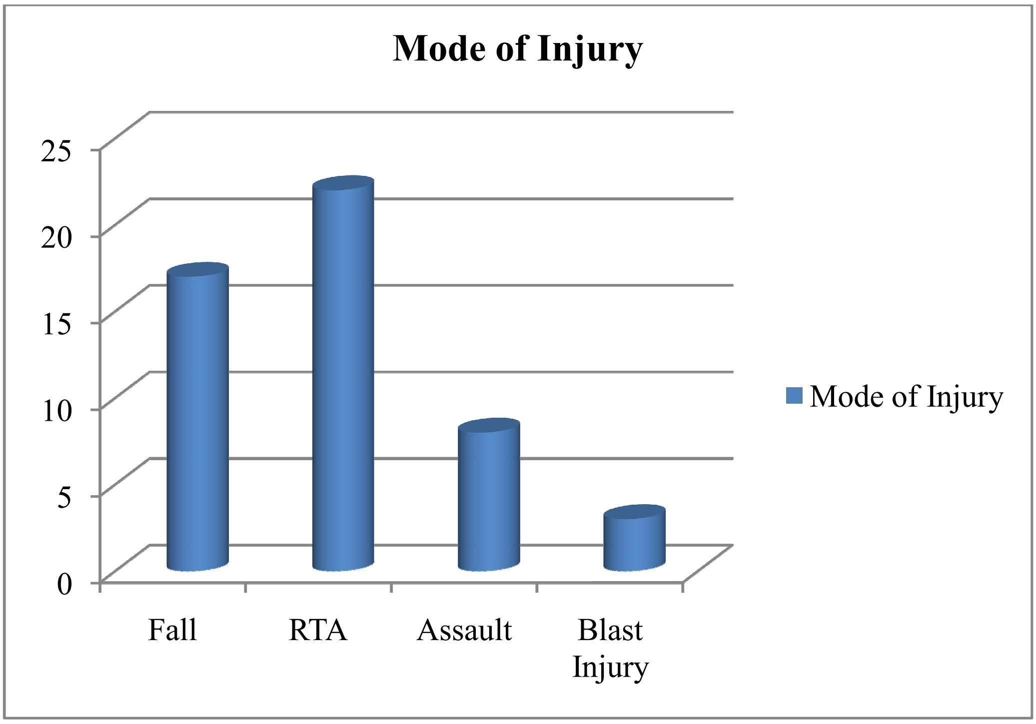


Figure 3 Mode of injury

5.4 Laterality

Laterality	Right	Left
	23	27

Table 4 Laterality

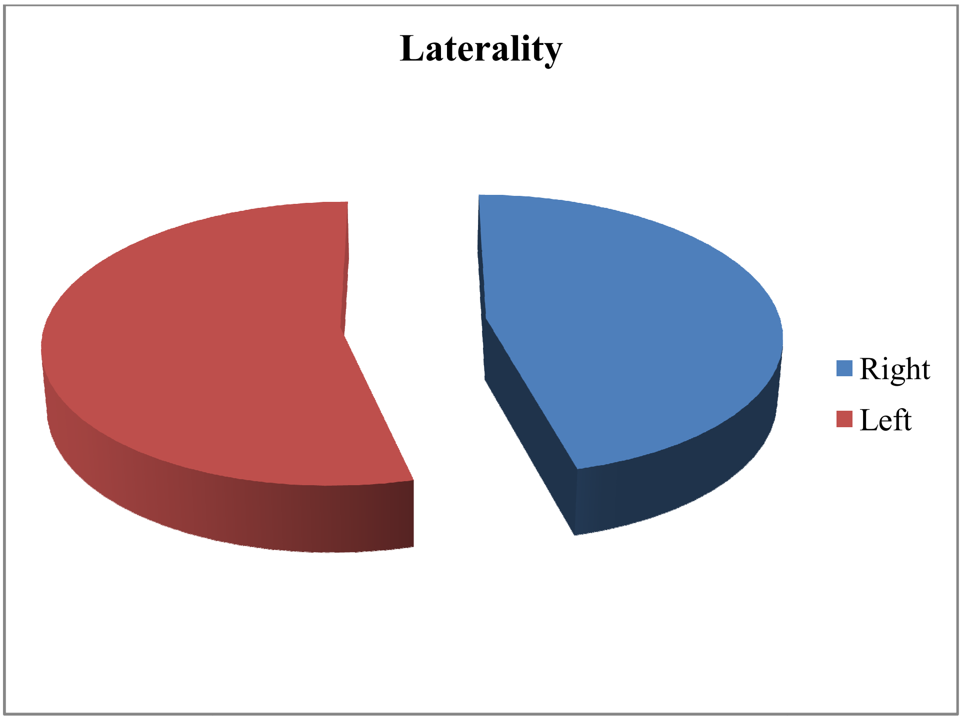


Figure 4 Laterality

5.5 FINGER INVOLVEMENT

Finger Involved	F1	F2	F3	F4	F5
	3	8	8	13	18

Table 5 Finger involvement

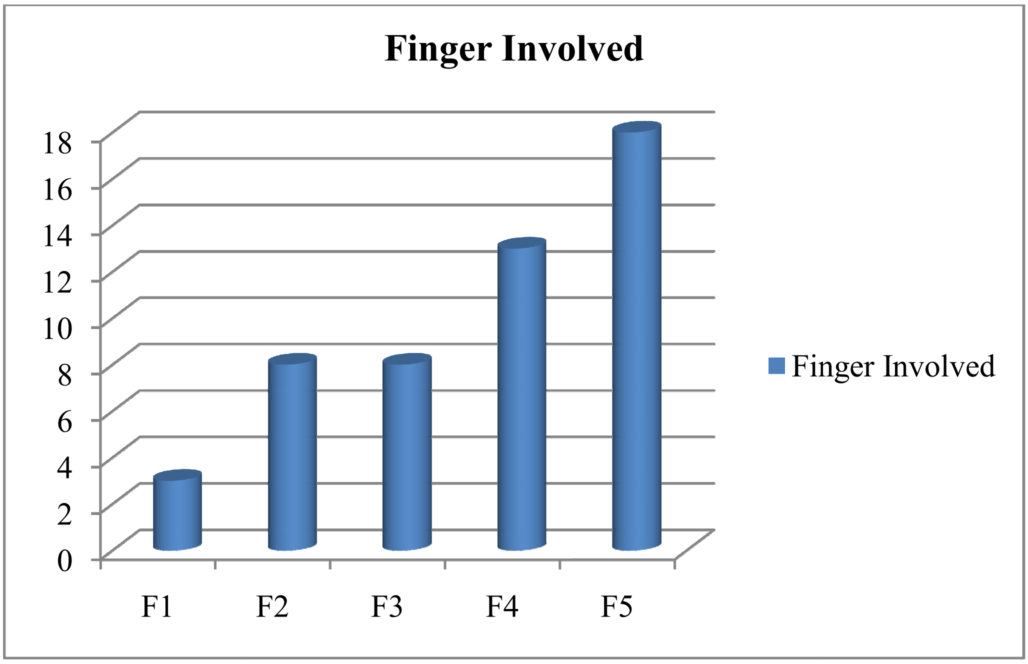


Figure 5 Finger involved

5.6 FRACTURE SITE

Fracture Site	Base	Shaft	Chondyle
	24	17	9

Table 6 Fracture site

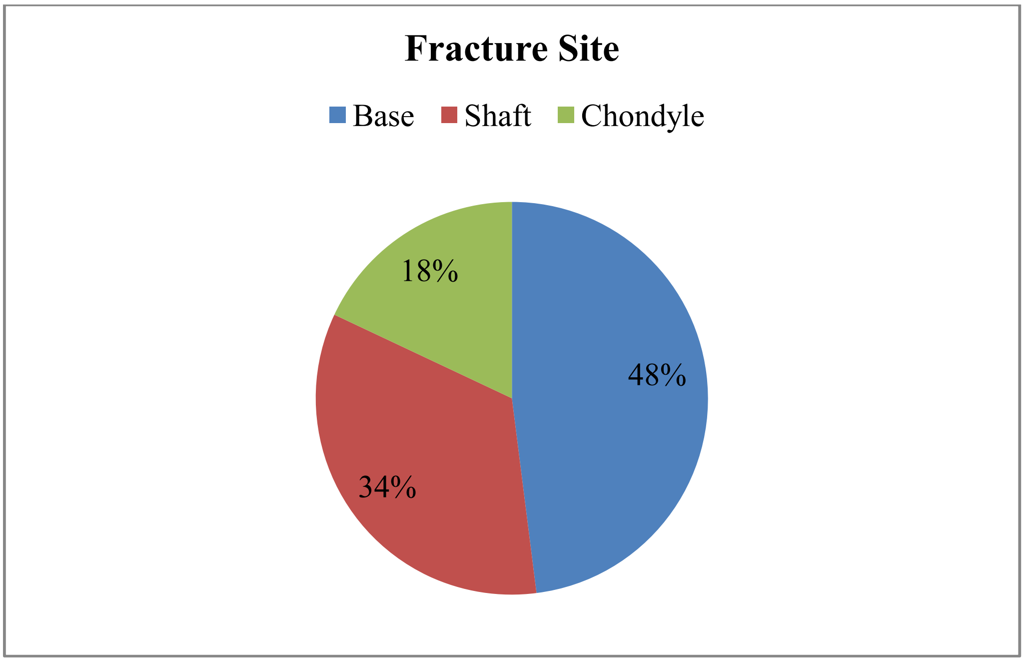


Figure 6 Fracture site

5.7 Type of fracture

Type of fracture	Communited	Oblique	Spiral	Transverse
	10	14	14	12

Table 7 Type of fracture

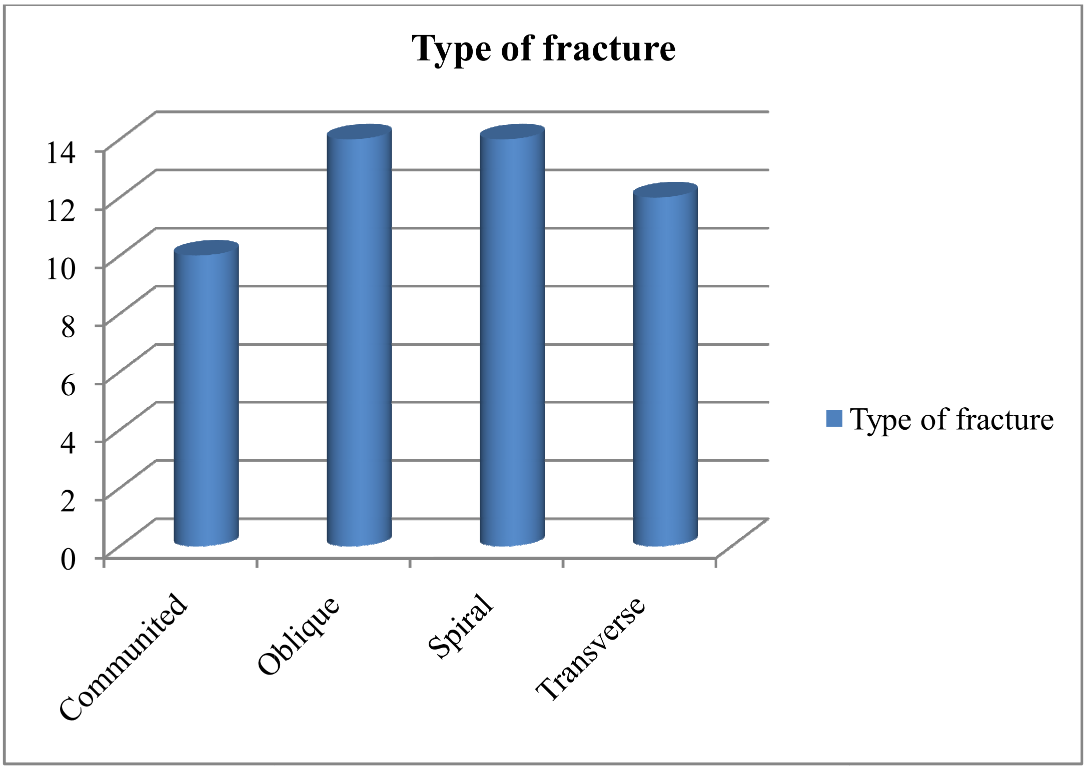


Figure 7 Type of fracture

5.8 Stability

Stability	Stable	Unstable
	12	38

Table 8 Stability

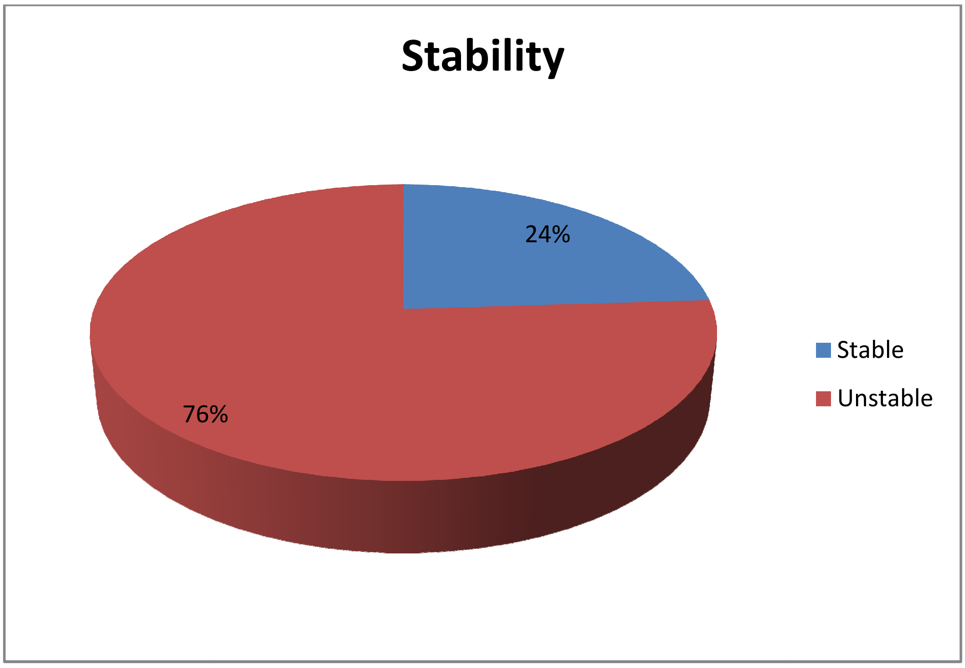


Figure 8 Stability

5.9 J0INT INVOLVEMENT

Joint Involvement	Yes	No
	7	43

Table 9 Joint involvement

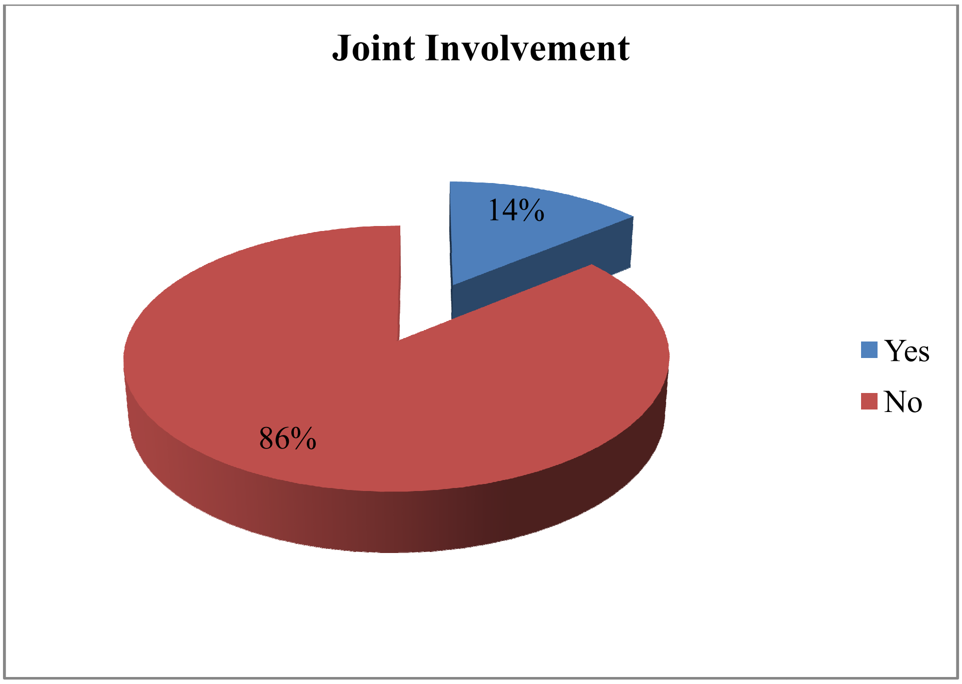


Figure 9 Joint involvement

5.10 Day of Intervention

Day of Intervention	1st	2nd	3rd	4th
	12	27	8	3

Table 10 Day of intervention

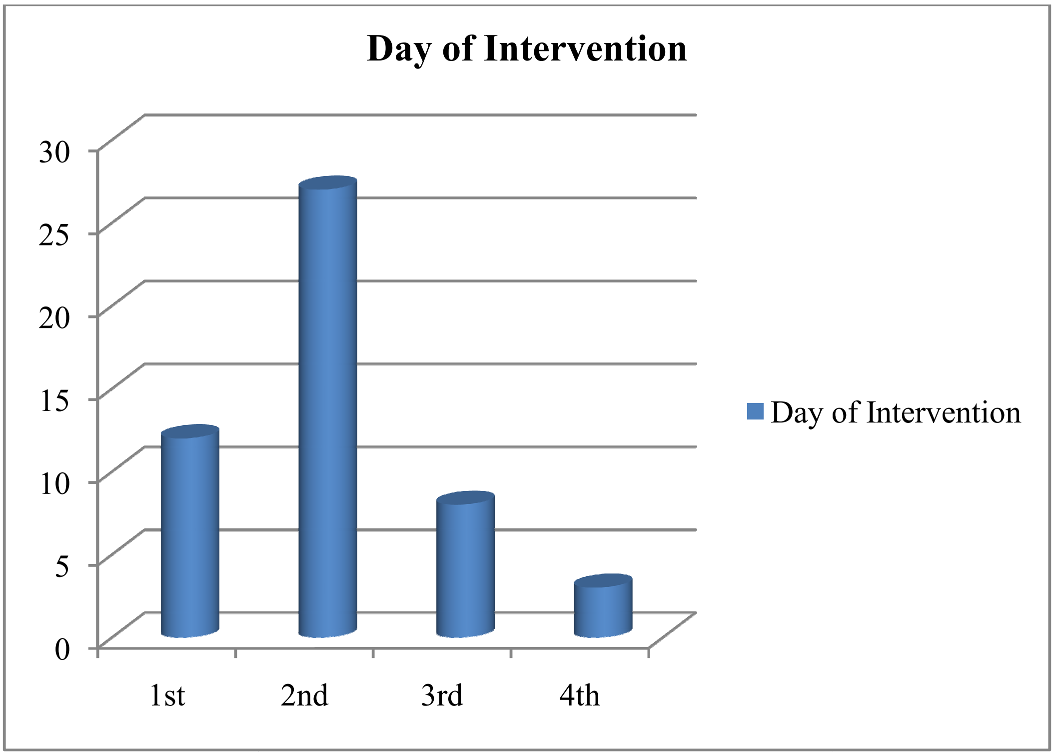


Figure 10 Day of intervention

5.11 MANAGEMENT

5.11.1 TYPE OF INTERVENTION

Type of Intervention	POP	ORIF	Ext. Fix
	12	29	9

Table 11 Type of intervention

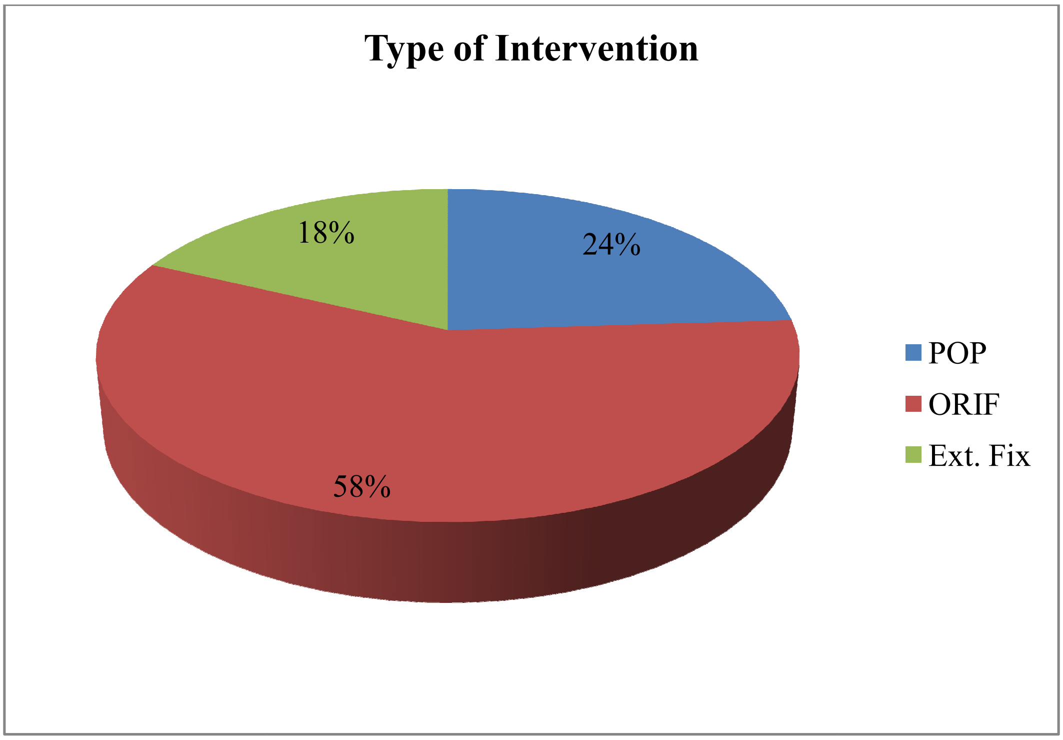


Figure 11 Type of intervention

5.12 POST OPERATIVE OUTCOME BASED ON PROCEDURES:

5.12.1 Conservative management: POP

5.12.2 Total range of movement

Sl.No.	TROM (degrees)	Count (No.s)
1	260	2
2	265	1
3	270	4
4	275	4
5	280	1

Table 12 Total range of movement

5.12.3 Grip Strength

Sl.No.	Grip Strength (%)	Count (No.s)
1	80	1
2	85	1
3	90	4
4	95	4
5	100	2

Table 13 Grip strength

5.12.4 Pinch Strength

Sl.No.	Pinch Strength (%)	Count (No.s)
1	85	1
2	90	4
3	95	3
4	100	4

Table 14 Pinch strength

5.12.5 Extensor lag

3 patients (5 degrees)

5.12.6 Flexor lag

2 patients (7 degrees)

5.12.7 Return to work

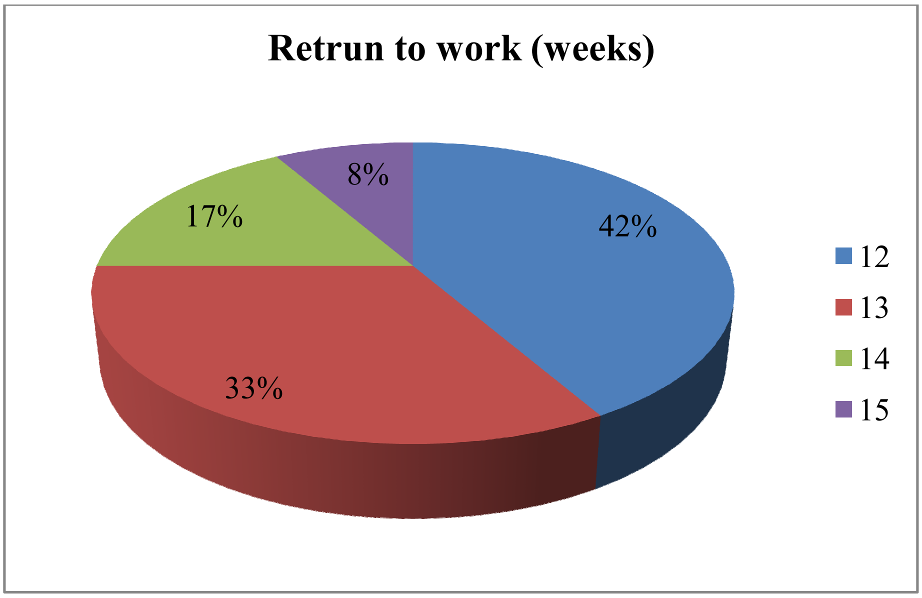


Figure 12 Return to work

5.13 ORIF (OPEN REDUCTION AND INTERNAL FIXATION)

5.13.1 Type of approach

Sl.No.	Type of approach	Count (No.s)
1	Dorsal approach	13
2	Lasy 's' incision	6
3	Lateral approach	8

Table 15 Type of approach

5.13.2 Total range of movement

Sl.No.	TROM (degrees)	Count (No.s)
1	230	1
2	253	1
3	265	3
4	270	7
5	275	7
6	280	10

Table 16 TROM

5.13.3 Grip Strength

Sl.No.	Grip Strength (%)	Count (No.s)
1	75	1
2	85	2
3	90	6
4	95	9
5	100	11

Table 17 Grip strength

5.13.4 Pinch Strength

Sl.No.	Pinch Strength (%)	Count (No.s)
1	85	1
2	90	11
3	95	6
4	100	11

Table 18 Pinch strength

5.13.5 Extensor lag

4 patients (5 degrees), 1 patient (7 degrees)

5.13.6 Flexor lag

4 patients (5 degrees)

5.13.7 Return to work

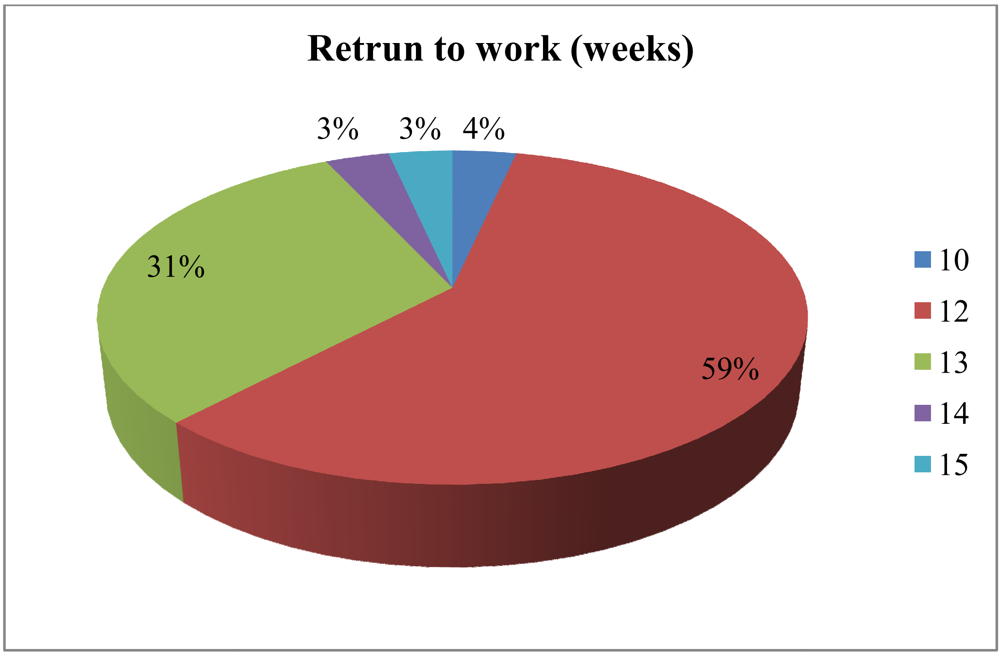


Table 19 Return to work

5.14 EXTERNAL FIXATION

5.14.1 Total range of movement

Sl.No.	TROM (degrees)	Count (No.s)
1	243	1
2	260	3
3	270	1
4	275	1
5	280	3

Table 20 TROM

5.14.2 Grip Strength

Sl.No.	Grip Strength (%)	Count (No.s)
1	75	1
2	85	2
3	90	2
4	95	1
5	100	3

Table 21 Grip strength

5.14.3 Pinch Strength

Sl.No.	Pinch Strength (%)	Count (No.s)
1	80	1
2	90	4
3	95	1
4	100	3

Table 22Pinch strength

5.14.4 Extensor lag

1 patient (5 degrees), 1 patient (7 degrees)

5.14.5 Flexor lag

2 patients (5 degrees)

5.14.6 Return to work

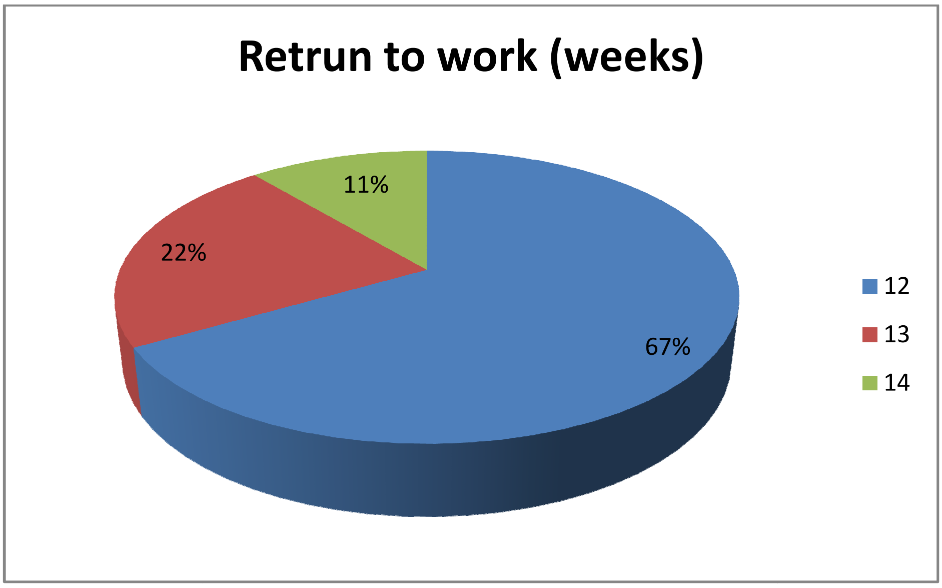


Figure 13 Return to work

5.15 PROCEDURE Vs OUTCOME

Procedure	Total cases	TROM		GRIP STRENGTH		PINCH STRENGTH		RETURN TO WORK IN 13 WEEKS
		>= 270 DEG		>= 90 %		>= 90 %		
POP	12	9	75%	10	83%	11	92%	75%
ORIF	29	24	83%	26	90%	28	97%	94%
EX.FIX	9	4	44%	6	67%	8	89%	89%

Table 23 Outcome

5.16 COMPLICATIONS

PIN TRACT INFECTION - 4 Pts

PIN LOOSENING - 3 Pts

MALUNION - 1 Pt

6 DISCUSSION

Outcome of proximal phalangeal fractures after management is based on the recovery of functions namely TROM (Total range of movement), Grip strength, Pinch strength in that finger and percentage of patients return to their work early.

In our study over a period of twelve months the above said functional outcomes have been analysed following proximal phalangeal fracture management.

6.1 ANALYSIS OF RESULTS:

INCIDENCE:

Out of 50 patients studied, males were commonly affected (88%). Commonest age group involved in between the age of 26 -35yrs.

Road traffic accidents being the predominant cause. Right hand is more commonly involved (54%). Out of five fingers F5 is more commonly involved (36%).

Among fracture sites, shaft is more commonly involved (48%). Oblique and spiral type of fractures is commonly encountered (56%) and most of the fractures are unstable (76%).

About 86% of patients are presented with joint involvement and about 78% of patients are intervened with in 2nd day of fracture.

6.2 PROCEDURE AND OUTCOME:

Most commonly performed procedure was open reduction and internal fixation (58%). Patients managed with POP in 24% of patients and external fixator in 18% of patients.

Post operatively, total range of movements (TROM) achieved up to 270 degree in

- 83% of patients treated with ORIF
- 75% of patients treated with POP,
- 44% of patients treated with external fixator.

Grip strength is achieved up to >= 90 % of normal strength in

- 90% of patients treated with ORIF
- 83% of patients in patients treated with POP
- 67% of patients treated with external fixator

Pinch strength achieved up to > = 90% of normal strength in

- 97% of patients treated with ORIF
- 92% of patients treated with POP
- 89% of patients treated with external fixator.

On analysing the outcome,

In case of conservative management,

42% of pts return to work in 12 weeks

33% of pts return to work in 13 weeks

17% of pts return to work in 14 weeks

8% of pts return to work in 15 weeks

In cses of pts treated with ORIF,

4% of pts return to work in 10 weeks

59% of pts return to work in 12 weeks

31% of pts return to work in 13 weeks

3% of pts return to work in 14 weeks

3% of pts return to work in 15 weeks

In case of pts managed with external fixation

67% of pts return to work in 12 weeks

22% of pts return to work in 13 weeks

11% of pts return to work in 14 weeks

About 94% of patients managed with ORIF, returned to their work within 13 weeks, 89% of patients managed with external fixator returned to their work in 13 weeks, and 75% of patients managed with POP returned to their work in 13 weeks.

6.3 COMPLICATIONS:

During post operative period,

Pin tract infection encountered in 4% of patients, pin loosening presented in 6% of patients and malunion in 2% of patients.

During follow up period,

In POP group	–	Extensor lag in 6% of pts
	–	Flexor lag in 4% of pts.
In ORIF group	–	Extensor lag in 8% of pts
	–	Flexor lag in 8% of pts.
In External fixator group	–	Extensor lag in 4% of pts
	–	Flexor lag in 4% of pts.

Based on the above results it was concluded that the average outcome was good in ORIF group and moderate in POP group.

The assessment of outcome helps in forming a protocol for the management of proximal phalangeal fractures and pinpoints the deficiencies existing in the management and the need to improve the already evolving management techniques.

Thus this study shows the importance of analysis of the outcome of proximal phalangeal fracture management there by critically evaluating and helping us to adopt methods of management of proximal phalangeal fractures which is still evolving to improve and prognosticate our results.

7 CONCLUSION

Hand fractures are more worthy of expertise as major extremity trauma, and the final outcome is a product of team work consisting of surgeon, anaesthetist, physiotherapist, occupational therapist and orthotist, amidst a highly motivated patient. The management of skeletal injuries of hand is a fine balancing act between the mobility and the stability on one hand and stiffness and adhesions on the other, and the surgeon as the leader of the team should modulate within his limits to tilt the balance in favour of mobility.

For most stable fractures, conservative treatment modalities are sufficient, but for most unstable fractures, surgical treatment gives the better results. Conservative treatment is a reliable, inexpensive modality, especially in children and in elderly age groups, but is associated with complication of malunion.

Open reduction and internal fixation is the most commonly done surgical procedure for a reducible, unstable fracture. It is a cost-effective, simple, and rapid procedure, and is well tolerated. It has added advantages of early bone healing, lesser infection rate, and decreased incidence of malunion. Strict adherence to post-treatment physiotherapy and rehabilitation is must to achieve the treatment objective and best possible outcome.

External fixator for hand injuries is a cheap, technically less demanding and an effective procedure. This procedure is mainly used in communited and intra articular fractures. This procedure not only corrects the deformity but also at the same time keeps the joint surface apart, thereby avoiding any crushing force on the bone cartilage. Also this is being a semi invasive procedure; it does not require bone and soft tissue resection.

8 CLINICAL PHOTOGRAPHS

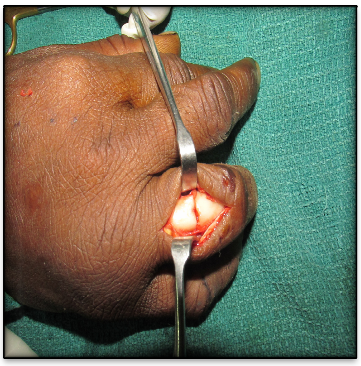
Open Reduction And Internal Fixation With 'K' Wires Fracture of PPX right F4

Pre Op- Xray

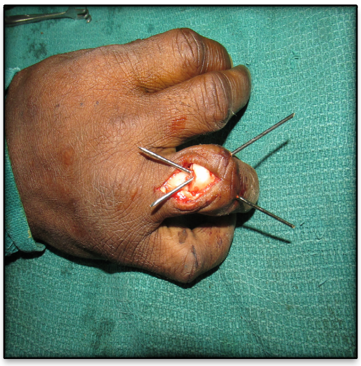
Pre Op-right F4

Dorsal Mid Line Spliting Incision

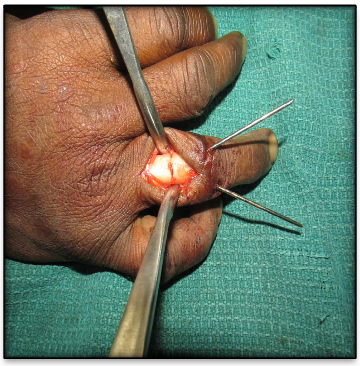
Transverse Fracture Line



Cross Two -K'wires



After Reduction



Extensor Tendon Suturing

Skin Suturing

Post Op X-ray

Conservative management with VOLAR POP

Pre Op Photo

Fracture PPX R- INTEX FINGER

Buddy Strapping

Volar POP

After 3 Weeks

External Fixator For Fracture PPX

Pre op x ray

External fixator

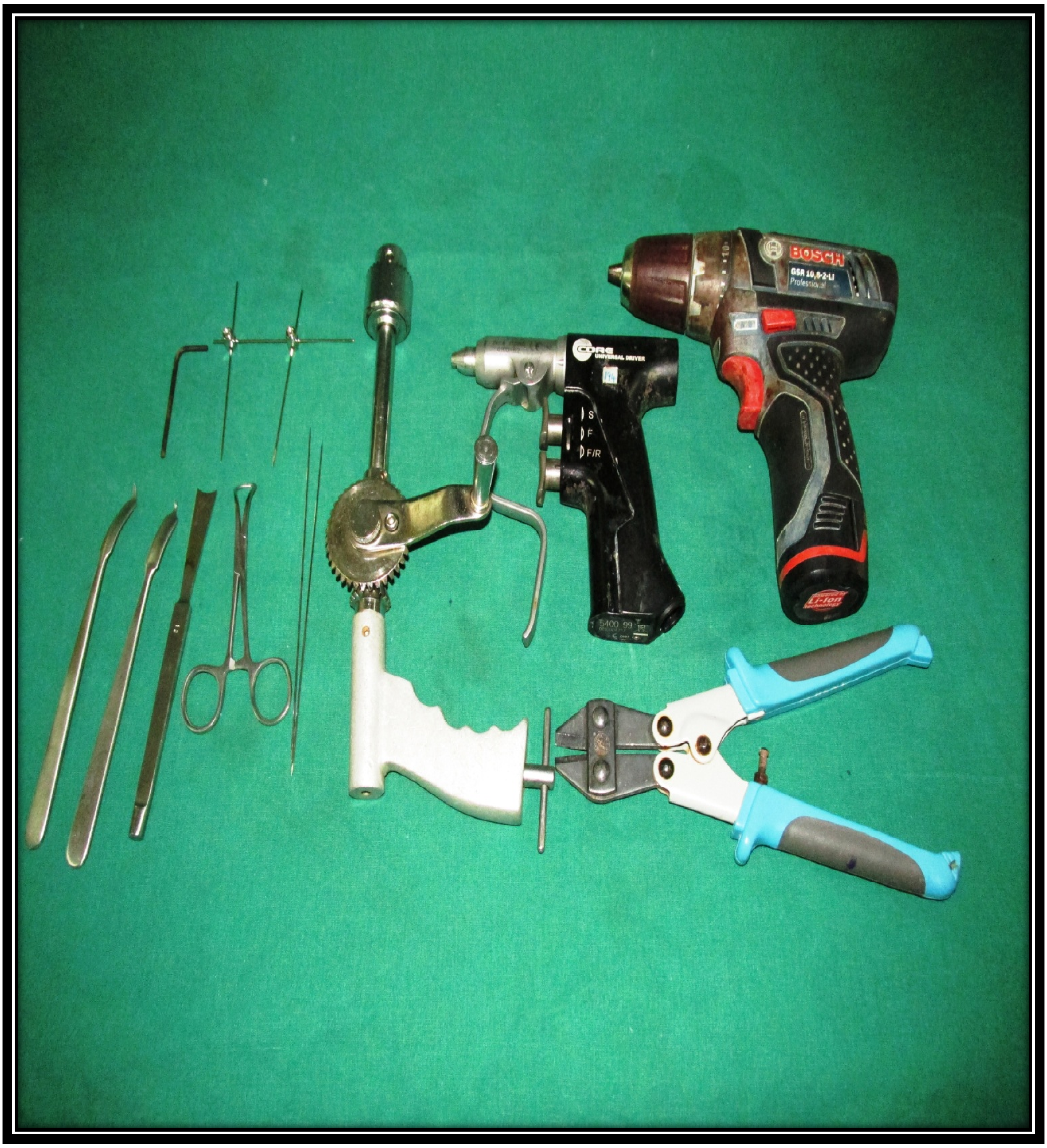
Post op x-ray

after 2 months followup

Hand grip measuring

ROM assessment

Materials Used



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9 APPENDIX – I

PROFORMA

NAME :

AGE :

SEX :

IP NO : PS NO :

ADDRESSS :

DOA :

DOS :

DOD :

I. HISTORY:

1. MODE OF INJURY:
    - RTA
    - FALL
    - ASSAULT
    - BLAST INJURY
2. How many days old injury
3. Smoking

II. CLINICAL EXAMINATION

- Laterality

- Finger involvement
- Deformity
- Active and passive range of movement
- Site of maximum tenderness

INVESTICATIONS

- X RAY HAND AP, LATERAL AND OBLIQUE
- HB%
- TC
- Blood sugar
- Serum creatinine
- HIV I AND II antibodies
- Chest X ray
- ECG

III. PREOPERATIVE TREATMENT

IV. OPERATIVE PROCEDURES PERFORMED

V. POST OPERATIVE RADIOGRAPHY

X RAY HAND - AP, LATERAL AND 45 degree OBLIQUE

VI. POST OPERATIVE TREATMENT

VII. POST OPERATIVE COMPLICATIONS

- PIN TRACT INFECTION
- PIN LOOSENING

VIII. K wire removal

IX. Physiotheraphy

X. Follow up and outcome assessment

- Active range of movement in DIP joint
- Active range of movement in PIP joint
- Active range of movement in MCP joint
- Total active range of movement
- Grip strength
- Pinch strength
- Extensor lag
- Flexor lag

XI. RETURN TO WORK

10 APPENDIX – II

Serial No	Name	Age	Sex	Mode of Injury	Laterality	Involving Finger	Fracture Site	Type Of Fracture	Stable/ Unstable	Joint Involvement	Day of Intervention After Injury	Method of Treatment
1	MRS. KK	28	F	Assault	Right	F2	Shaft	Oblique	Unstable	No	4	ORIF
2	MR.RK	42	M	H/O Fall	Left	F4	condyle	Communited	Unstable	Yes	2	External fixation
3	MR.A	15	M	RTA	Right	F4	Base	Transverse	Stable	No	2	POP
4	MR.RK	30	M	RTA	Right	F4	Base	Spiral	Unstable	No	3	ORIF
5	MR.A	40	M	H/O Fall	Left	F3	Base	Spiral	Unstable	No	2	ORIF
6	MR. R	40	M	H/O Fall	Right	F5	condyle	Oblique	Unstable	No	3	ORIF
7	MR. B	17	M	H/O Fall	Left	F5	Base	Transverse	Stable	No	2	POP
8	MR. M	52	M	RTA	Left	F5	Base	Transverse	Stable	No	4	POP
9	MR.G	30	M	H/O Fall	Right	F4	Shaft	Oblique	Unstable	No	2	ORIF
10	MR.G	35	M	RTA	Left	F4	Shaft	Transverse	Stable	No	3	POP
11	MR.D	23	M	Blast injury	Left	F1	Base	Spiral	Unstable	No	2	ORIF
12	MR.K	30	M	RTA	Left	F5	condyle	Spiral	Unstable	No	3	ORIF
13	MR.V	21	M	RTA	Right	F5	Base	Communited	Unstable	No	2	External fixation
14	MR.A	20	M	RTA	Left	F4	Shaft	Transverse	Stable	No	3	POP
15	MR.V	45	M	Assault	Right	F4	Shaft	Oblique	Unstable	No	2	ORIF

Serial No	Name	Age	Sex	Mode of Injury	Laterality	Involving Finger	Fracture Site	Type Of Fracture	Stable/ Unstable	Joint Involvement	Day of Intervention After Injury	Method of Treatment
16	MR. K	35	M	RTA	Right	F3	Shaft	Communited	Unstable	No	1	External fixation
17	MR.D	43	M	Assault	Left	F5	Base	Spiral	Unstable	No	2	ORIF
18	MR.T	40	M	RTA	Left	F4	condyle	Oblique	Unstable	No	1	ORIF
19	MRS.T	48	F	H/O Fall	Left	F1	condyle	Spiral	Unstable	No	2	ORIF
20	MR.Y	35	M	Assault	Right	F4	Shaft	Transverse	Stable	No	1	POP
21	MR.B	38	M	H/O Fall	Right	F4	Shaft	Spiral	Unstable	No	2	ORIF
22	MR.R	23	M	Assault	Right	F3	Base	Transverse	Stable	No	4	POP
23	MR.K	32	M	H/O Fall	Left	F3	Base	Communited	Unstable	Yes	2	External fixation
24	MR.RK	47	M	RTA	Right	F3	Shaft	Transverse	Stable	No	3	POP
25	MRS.R	22	F	Assault	Left	F2	Base	Communited	Unstable	Yes	2	External fixation
26	MR.M	42	M	H/O Fall	Left	F3	Shaft	Spiral	Unstable	No	1	ORIF
27	MR.K	55	M	RTA	Left	F5	Base	Spiral	Unstable	No	2	ORIF
28	MR.M	40	M	RTA	Left	F2	Shaft	Transverse	Stable	No	2	POP
29	MRS.A	29	F	H/O Fall	Right	F3	condyle	Oblique	Unstable	No	2	ORIF
30	MR.B	30	M	RTA	Left	F4	Base	Communited	Unstable	Yes	2	External fixation

Serial No	Name	Age	Sex	Mode of Injury	Laterality	Involving Finger	Fracture Site	Type Of Fracture	Stable/ Unstable	Joint Involvement	Day of Intervention After Injury	Method of Treatment
31	MR.V	40	M	Blast injury	Right	F5	Base	Spiral	Unstable	Yes	2	ORIF
32	MR.T	25	M	Blast injury	Right	F2	Base	Oblique	Unstable	No	1	ORIF
33	MR.T	35	M	RTA	Left	F5	Base	Spiral	Unstable	No	2	ORIF
34	MR.P	40	M	Assault	Right	F1	Shaft	Transverse	Stable	No	2	POP
35	MR. M	24	M	RTA	Left	F5	Base	Communited	Unstable	Yes	1	External fixation
36	MR.S	28	M	H/O Fall	Right	F4	condyle	Spiral	Unstable	No	2	ORIF
37	MR.P	22	M	RTA	Left	F4	Base	Spiral	Unstable	No	1	ORIF
38	MR.K	26	M	RTA	Left	F5	Base	Communited	Unstable	Yes	2	External fixation
39	MR.S	55	M	H/O Fall	Left	F5	Shaft	Transverse	Stable	No	1	POP
40	MR.N	15	M	H/O Fall	Left	F5	Base	Oblique	Unstable	No	1	ORIF
41	MR.P	44	M	Assault	Right	F2	Shaft	Communited	Unstable	No	3	External fixation
42	MR.M	19	M	RTA	Left	F5	condyle	Oblique	Unstable	No	2	ORIF
43	MRS,S	55	F	H/O Fall	Right	F5	Base	Transverse	Stable	No	1	POP
44	MR.S	26	M	RTA	Left	F2	Shaft	Oblique	Unstable	No	3	ORIF
45	MR.M	48	M	RTA	Right	F5	Shaft	Oblique	Unstable	No	2	ORIF
46	MR.k	52	M	RTA	Left	F5	Base	Spiral	Unstable	No	2	ORIF
47	MR. A	16	M	H/O Fall	Left	F3	Base	Communited	Unstable	No	2	ORIF
48	MR.K	27	M	RTA	Right	F2	condyle	Oblique	Unstable	No	2	ORIF
49	MRS.U	39	F	H/O Fall	Right	F2	Base	Oblique	Unstable	No	1	ORIF
50	Mr.R	44	M	H/O Fall	Right	F5	Shaft	Oblique	Unstable	No	1	ORIF

Serial No	Name	Type of Incision	Pop /K Wire Removal on	Arom-Mcp In Degrees	Arom - Pip In Degrees	Arom-Dip in Degrees	Total Range of Movements in Degrees	Grip Strength in Percentage	Pinch Strength in Percentage	Extensor Lag in Degrees	Flexion Lag in Degrees	Return to Work in Weeks
1	MRS. KK	Dorsal approach	3 weeks	0-90	0-90	0-90	270	95	90	0	0	13
2	MR.RK		4 weeks	0-90	5-90	0-90	270	85	90	0	0	12
3	MR.A		3 weeks	0-85	0-90	0-85	260	90	90	0	0	14
4	MR.RK	Lateral approach	3 weeks	0-90	7-90	0-80	253	95	100	5	0	12
5	MR.A	Lateral approach	3 weeks	0-85	0-100	0-90	275	100	100	0	0	10
6	MR. R	Lasy 's' incision	3 weeks	0-95	0-95	0-90	280	95	95	0	5	13
7	MR. B		3 weeks	0-90	0-100	0-80	270	90	100	0	0	12
8	MR. M		3 weeks	0-100	0-85	0-90	275	100	100	0	0	13
9	MR.G	Lateral approach	4 weeks	0-90	0-90	0-90	270	95	95	0	5	14
10	MR.G		3 weeks	0-90	0-90	0-85	265	80	90	5	7	15
11	MR.D	Dorsal approach	3 weeks	0-85	0-90	0-90	265	90	90	0	0	13
12	MR.K	Lasy 's' incision	3 weeks	0-90	0-100	0-90	280	100	100	0	0	12
13	MR.V		4 weeks	0-90	5-85	0-90	260	90	90	0	0	12
14	MR.A		3 weeks	0-85	0-100	0-90	275	95	95	0	0	12
15	MR.V	Dorsal approach	3 weeks	0-100	0-90	0-90	270	100	100	0	0	12

Serial No	Name	Type of Incision	Pop /K Wire Removal on	Arom-Mcp In Degrees	Arom - Pip In Degrees	Arom-Dip in Degrees	Total Range of Movements in Degrees	Grip Strength in Percentage	Pinch Strength in Percentage	Extensor Lag in Degrees	Flexion Lag in Degrees	Return to Work in Weeks
16	MR. K		3 weeks	0-90	0-85	0-85	260	90	90	0	5	13
17	MR.D	Dorsal approach	3 weeks	0-100	0-90	0-90	280	100	100	0	0	12
18	MR.T	Lateral approach	4 weeks	0-100	0-100	0-80	280	100	100	0	0	12
19	MRS.T	Lasy 's' incision	3 weeks	0-95	0-90	0-90	275	100	90	0	5	13
20	MR.Y		3 weeks	0-95	0-95	0-80	270	95	90	0	0	13
21	MR.B	Dorsal approach	4 weeks	0-100	0-90	0-90	280	100	100	0	0	12
22	MR.R		3 weeks	0-95	0-100	0-80	275	95	95	0	0	12
23	MR.K		3 weeks	0-100	0-90	0-90	280	100	100	0	0	12
24	MR.RK		3 weeks	0-95	0-95	0-80	270	95	100	5	0	13
25	MRS.R		3 weeks	0-95	0-90	0-90	280	100	100	0	0	12
26	MR.M	Dorsal approach	3 weeks	0-100	0-90	0-80	270	95	95	0	0	13
27	MR.K	Lasy 's' incision	4 weeks	0-80	5-90	5-70	230	75	85	7	5	15
28	MR.M		3 weeks	0-95	0-90	0-90	275	100	100	0	0	12
29	MRS.A	Dorsal approach	3 weeks	0-90	0-95	0-90	275	100	100	0	0	12
30	MR.B		4 weeks	0-95	0-100	0-80	275	95	95	0	0	12

Serial No	Name	Type of Incision	Pop /K Wire Removal on	Arom- Mcp In Degrees	Arom - Pip In Degrees	Arom- Dip in Degrees	Total Range of Movements in Degrees	Grip Strength in Percentage	Pinch Strength in Percentage	Extensor Lag in Degrees	Flexion Lag in Degrees	Return to Work in Weeks
31	MR.V	Lateral approach	3 weeks	0-90	0-95	0-90	280	95	90	5	0	13
32	MR.T	Dorsal approach	3 weeks	0-90	0-90	0-*90*	270	95	95	0	0	13
33	MR.T	Lateral approach	3 weeks	0-95	0-90	0-90	275	95	95	0	0	13
34	MR.P		3 weeks	0-90	0-90	0-90	270	90	90	0	0	12
35	MR. M		3 weeks	0-85	0-90	0-85	260	85	90	5	0	13
36	MR.S	Dorsal approach	4 weeks	0-90	0-90	0-85	265	85	90	5	0	12
37	MR.P	Lasy 's' incision	3 weeks	0-95	0-100	0-85	280	90	95	0	0	12
38	MR.K		3 weeks	0-80	7-85	5-90	243	75	80	7	5	14
39	MR.S		3 weeks	0-100	0-95	0-85	280	90	95	0	0	13
40	MR.N	Dorsal approach	4 weeks	0-100	0-90	0-90	280	100	100	0	0	12
41	MR.P		3 weeks	0-95	0-95	0-90	280	100	100	0	0	12
42	MR.M	Dorsal approach	3 weeks	0-100	0-90	0-85	275	95	90	0	0	12
43	MRS,S		3 weeks	0-85	0-100	0-75	260	85	85	5	7	14
44	MR.S	Dorsal approach	4 weeks	0-100	0-90	0-90	280	100	100	0	0	12
45	MR.M	Lateral approach	3 weeks	0-95	0-90	0-80	265	90	90	0	0	13

46	MR.k	Lasy 's' incision	3 weeks	0-90	0-95	0-90	275	85	90	5	0	12
47	MR. A	Lateral approach	4 weeks	0-100	0-90	0-85	275	90	90	0	0	12
48	MR.K	Dorsal approach	3 weeks	0-90	0-100	0-90	280	100	100	0	0	12
49	MRS.U	Lateral approach	3 weeks	0-100	0-90	0-80	270	90	90	0	0	12
50	Mr.R	Lateral approach	3 weeks	0-100	0-90	0-80	270	90	90	0	0	12